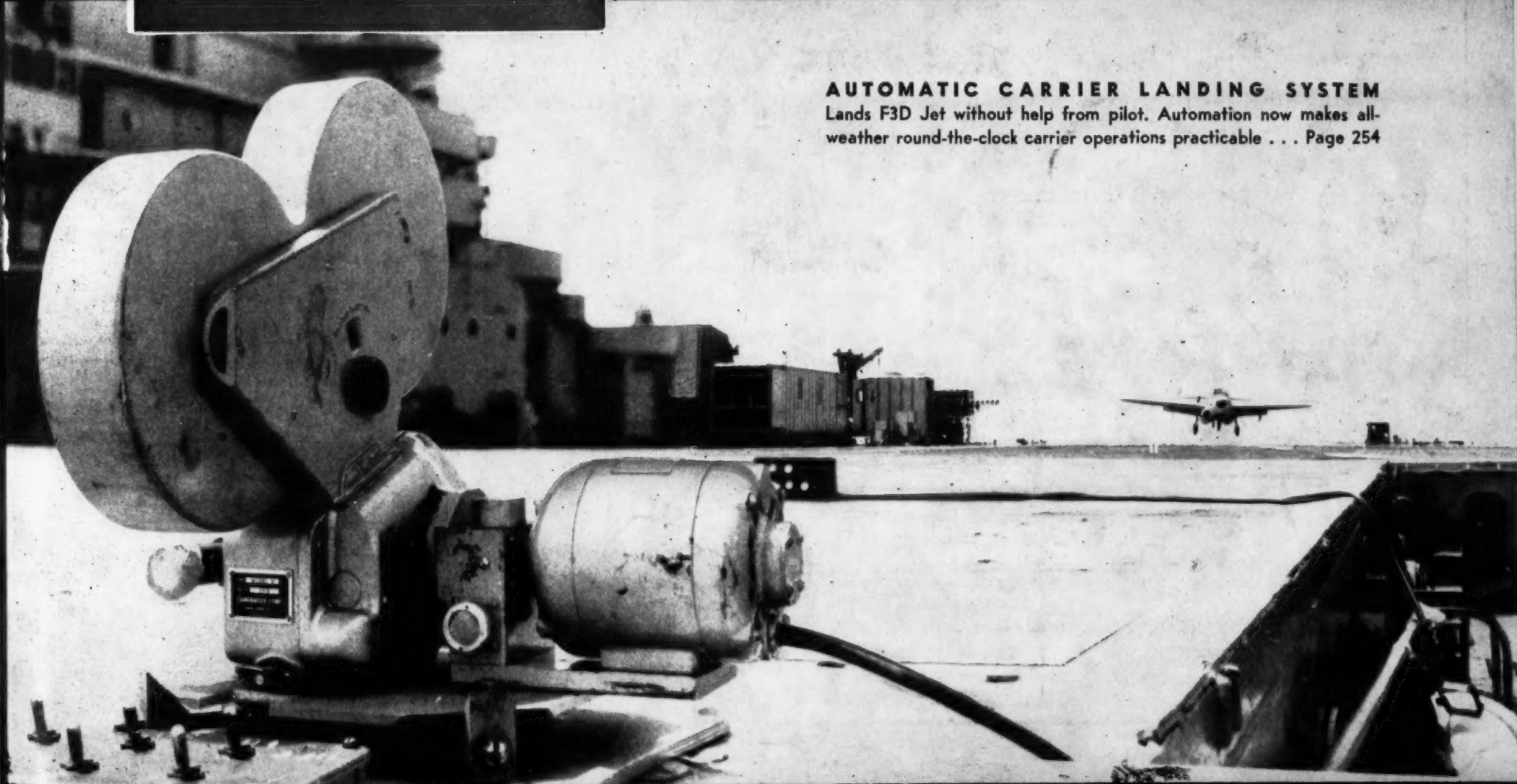


M

A

AUTOMATIC CARRIER LANDING SYSTEM

Lands F3D Jet without help from pilot. Automation now makes all-weather round-the-clock carrier operations practicable . . . Page 254



IN THIS ISSUE . . .

. . . we report an important breakthrough in military automation—the first successful automatic landing of a Navy jet aircraft aboard its carrier. Adaptable to land-based and civilian planes as well, automatic landing techniques should greatly increase the safety of all flying and the tactical value of carrier task forces.

The historical setting and events leading up to the invention of the klystron are told for the first time by its inventor, Dr. Russell H. Varian, Varian Associates, on pages 256-259.

The high order of navigational accuracy required by modern warfare is reflected by the Navy's interest in radio telescope principles as an aid to all-weather celestial navigation. This story is told in "Radio-metric Inertial Reference" on pages 278-281, explaining a development of the Research and Development Division, Collins Radio Co.

To our current series on Servos and Printed Circuit Techniques, we now add a third—"Microwave Techniques," which will be amplified in forthcoming issues. This is a new regular feature and another important educational effort.

Routine waveform and voltage tests have long been used to detect incipient malfunction in radars. An enterprising Signal Corps sergeant in charge of search radar in the Russell Islands (1953) simplified this test procedure by bringing all scope test points out to a multipoint switch and jack on the panel. The featurette, "Failure Predictor Improves Radar Reliability," shows how techniques of automation are applied to testing radar receiver parameters.

Missile and gun projectile propellant is a specialized technique treated in pictorial featurette—"Internal Ballistics" on page 282.

A new regular feature, "Circuitry for Military Applications," explains typical circuits used in military electronics equipment.

Any person who absorbs more than his normal share of misfortune but forges to the top despite that handicap earns our admiration. Our Bio-Bit subject, Mr. Ira Kamen, engineer and author, certainly qualifies for this category.

Navy Day, now officially merged into Armed Forces Day, has traditionally been celebrated on October 26. Our editorial "Navy Day Oct. 26, 1942" recalls a dark hour in World War II.

Economy of mass production

Temperature controlled network oven

Extra bay for custom expansion

Highest component accuracy

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Digital (AERO) Automatic Extended Readout

100% shielded patching facility

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Economic building-block expansion.

For details on this **PACE** Analog Computer Group 131R and on time rental at EAI's Computation Centers—serving eastern industry in Princeton, New Jersey—serving Western industry in Los Angeles, California—serving European industry at Brussels, Belgium, write Electronic Associates, Inc., Dept. MA-9, Long Branch, New Jersey.

ELECTRONIC ASSOCIATES
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EAI SETS THE

P A C E
PRECISION ANALOG COMPUTING EQUIPMENT

LONG BRANCH • NEW JERSEY

For more information circle 1 on inquiry card.

MA

VOL. 1, NO. 5

SEPT.-OCT.

1957

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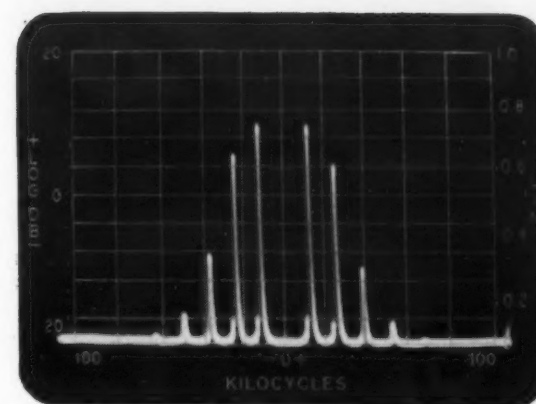
Regular Features

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September-October, 1957

FM Deviation Check
4.3 kc. modulation
at first carrier null.

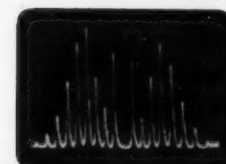
Deviation =
±10.32 kc. Panor-
amic display shows
actual sideband
spread including
those beyond
deviation.



FM problems?

pictures like these
give the answers
you need for FM
operating and
equipment
testing

Two photos showing FM
signals of equal deviations
(±55.2 kc) but different
energy distributions. FM
deviation monitor would
read identically in both
tests.



10 kc modulation
at second carrier
null

Same modulation
level—frequency
1 kc

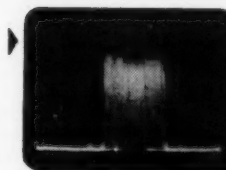


with a **PANORAMIC
PANALYZOR**

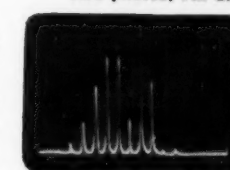
you can

- Determine sideband spillover . . . assure conformance with statutory bandwidth restrictions of sideband energy
- See RAPIDLY the frequency vs amplitude contents of FM signals . . . compare relative magnitudes of FM frequency components
- Measure deviation precisely through carrier and sideband nulls
- Observe clearly sideband structure under complex forms of modulation
- Analyze carrier shifts, incidental AM, hum, RF harmonics non-linearities . . . detect carrier pulling or instability in both magnitude and direction
- Adjust operating parameters at optimum

Major regions of FM
system sideband energy
due to speech modula-
tion clearly illustrated
on Panalyzer. Slow scans
aid in visual apprecia-
tion of average
envelope. Extended
exposure photographs
also are valuable for
complex wave analysis.

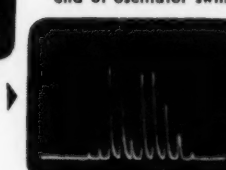


Two photos; FM due to clipped sine wave



Relative lack of
sidebands to left of
carrier (centered on
Panalyzer screen)
indicate limited
deviation on clipped
end of oscillator swing.

Here the other side is
clipped. Note mirror
image effect and slight
carrier shift.



Send for our new
CATALOG DIGEST and
ask to be put on the
mailing list for THE
PANORAMIC ANALYZER,
our regular bulletin
featuring application data.



the pioneer
is the leader

3 models . . . 9 types meet
almost every need . . .
present a full graphic picture
of incomparable value . . .
provide a measuring tool of
utmost simplicity, complete
reliability, tremendous flexibility.

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formation TODAY. A Panoramic
Applications Engineer is always available
to discuss specific problems.

PANORAMIC RADIO PRODUCTS, Inc., 518 South Fulton Ave., Mount Vernon, N.Y.

Phone: OWens 9-4600 • Cables: Panoramic, Mount Vernon, N. Y. State

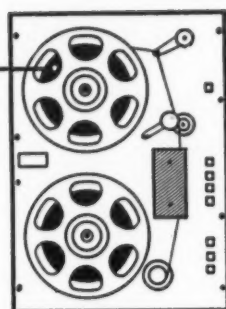
For more information circle 2 on inquiry card.

HYCON EASTERN

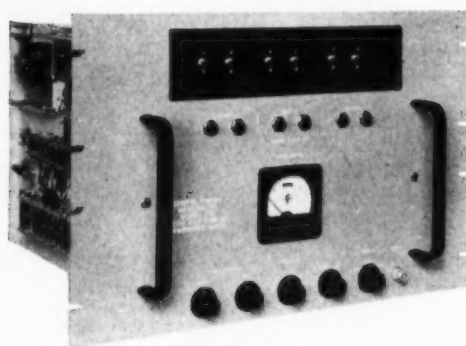
RAPID ACCESS

IN ANALOG DATA

REDUCTION SYSTEMS



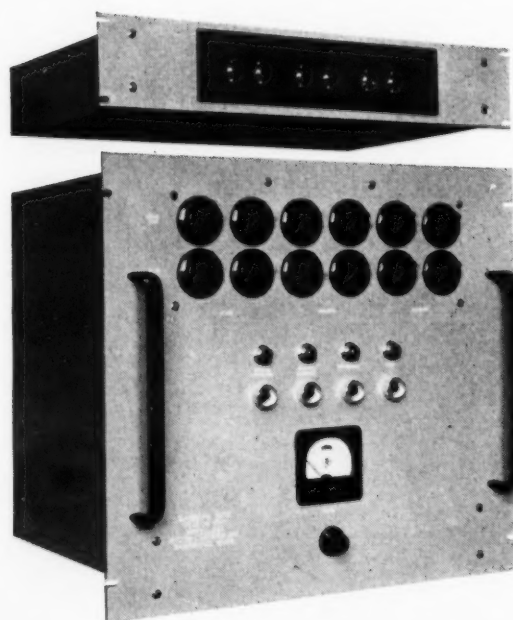
Two companion units by Hycon Eastern provide automatic high-speed access to selected data in Ampex Recorders and similar multi-channel magnetic tape instrumentation systems.



For Tape Indexing

DIGITAL TIMING GENERATOR, MODEL 201, generates numerically coded timing signals which are recorded on the magnetic tape throughout the data recording periods, providing a precise digital index in terms of elapsed time. The Generator also visually displays the exact time in hours, minutes and seconds as illuminated digits.

MODEL 206A IS A MILITARIZED AIRBORNE VERSION OF MODEL 201.



For Tape Search

MAGNETIC TAPE SEARCH UNIT, MODEL 202, operates during data reduction periods. On the basis of time indices recorded on the tape by the Digital Timing Generator, this instrument automatically locates and selects for controlled playback the tape data included between a "sequence start time" and a "sequence end time" specified by panel dial settings. The time index is visually displayed as illuminated digits on a small separate panel which may be remotely located for convenience. Model 202 may be modified to search for timing formats other than those originated by Model 201.

Write for Technical Bulletin TSG-O

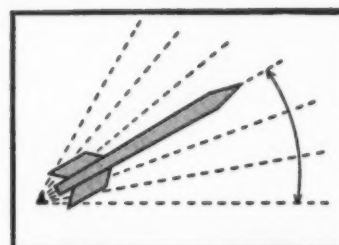


HYCON EASTERN, INC.

75 Cambridge Parkway Dept. U-10 Cambridge 42, Mass.

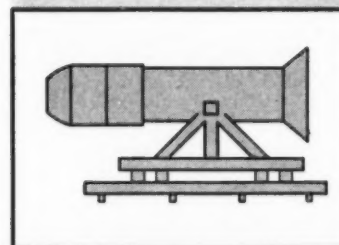
Affiliated with HYCON MFG. COMPANY, Pasadena, California

For more information circle 3 on inquiry card.



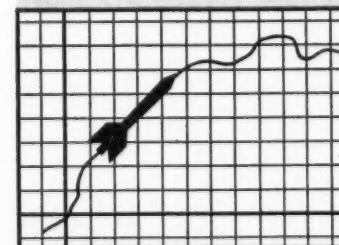
WIND TUNNEL TESTING

Pressure and temperature data of a supersonic missile are referenced to its angle of attack. Digital Timing Generator, Model 201, records on tape a digitized position signal for each new angle of attack setting.



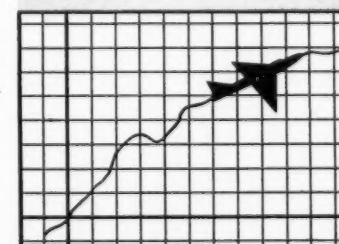
JET ENGINE TESTING

Digital Timing Generator, Model 201, is used to synchronize all data receiving equipment. The output of Model 201 can be piped to multiple test cells and control rooms simultaneously.



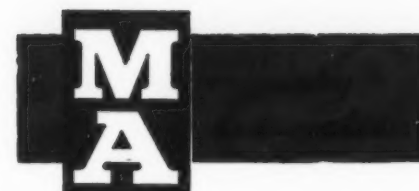
MISSILE TESTING

Digital Timing Generator, Model 201, is used for synchronizing ground station recording of signals simultaneously with telemetered data from the missile in flight.



AIRCRAFT FLIGHT TESTING

Digital Timing Generator, Model 206A, is designed specifically for airborne recording. Timing signals are recorded simultaneously with other flight test data.



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MILITARY AUTOMATION

Sputnik's Weight

The reported weight (185 lbs) of the 22" dia Red satellite has been questioned by some of our scientists. Our 20" globelet is planned for 21½ lbs. Whether Sputnik weighs 18 or 180 lbs may determine the true measure of Russia's achievement. The heavier figure is an accomplishment that would justify all the concern that has been voiced since October 4.

Increased activity in vital rocket research and development should become evident in the near future, together with accelerated production of interim missiles and supersonic aircraft. Is Sputnik chiefly a publicity coup? Cleverly utilized as an indication of military capacity, it challenges the foundations of our world leadership.

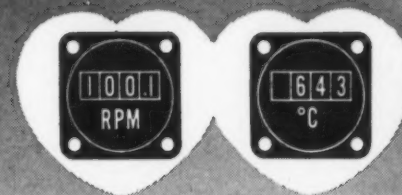
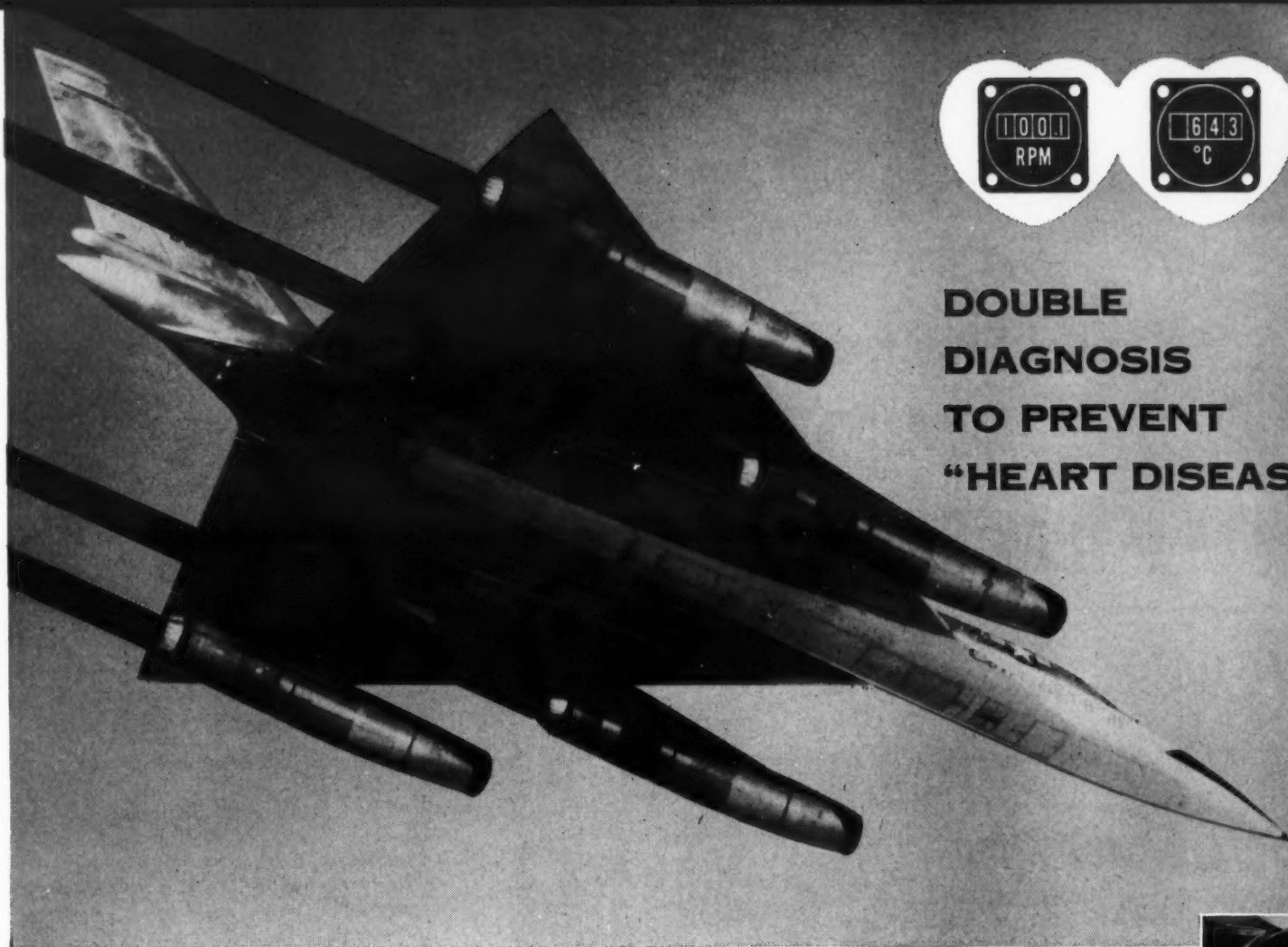
In Preparation

Our final issue of Volume I will continue development of our Servo, Printed Circuit, UHF Techniques, and Military Circuitry series. Also scheduled for early appearance are a review of Fire Control systems, a survey of analog-digital converters and their applications, Wind Tunnel testing, Naval Model Basin instrumentation, and operational testing of ship's electronics systems.

Other articles in preparation include forward-scatter communications; tutorial articles on applications of klystron, magnetron, backward wave and traveling-wave tubes; automatic assembly of components; information retrieval systems; ferrite and magnetic amplifier applications; radiac measurements; and government specifications. We also expect to soon have outstanding articles on systems and component reliability, and a survey of simulation devices used in military training. A basic article on gyroscopes and other direction referencing techniques also is in preparation.

* * *

The addition of the words "DATA HANDLING" to our cover must be credited to a suggestion made by Mr. Don Prell, Advertising Manager of Benson-Lehner Corporation, Los Angeles, who says, "M-A is outstanding in its treatment of data-handling, information retrieval, and computers used by the military. Why don't you take credit for it?" Although we don't want to neglect any phase of controls and automation applied to military uses, we fully agree with Mr. Prell that this important phase should be headlined—and thanks for the compliment, Mr. Prell.



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DIAGNOSIS
TO PREVENT
"HEART DISEASE"**

...BY THE B&H

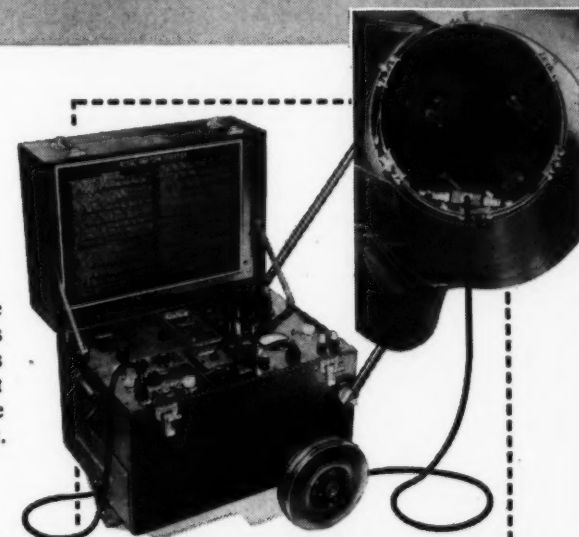
JETCAL ANALYZER

Two of the most important factors that affect jet engine life, efficiency, and safe operation are *Exhaust Gas Temperature (EGT)* and *Engine Speed (RPM)*. Excess heat will reduce "bucket" life as much as 50% and low EGT materially reduces efficiency and thrust. Any of such conditions will make operation of the aircraft both costly and dangerous. The *JETCAL Analyzer* predetermines accuracy of the EGT and (interrelatedly) Tachometer systems and isolates errors if they exist.

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- 1) The JETCAL Analyzer functionally tests EGT thermocouple circuit of a jet aircraft or pilotless aircraft missile for error without running the engine or disconnecting any wiring. GUARANTEED ACCURACY is $\pm 4^\circ\text{C}$. at engine test temperature.
- 2) Checks individual thermocouples "on the bench" before placement in parallel harness.
- 3) Checks thermocouples within the harness for continuity.
- 4) Checks thermocouples and paralleling harness for accuracy.
- 5) Checks resistance of the Exhaust Gas Temperature system.
- 6) Checks insulation of the EGT circuit for shorts to ground and for shorts between leads.
- 7) Checks EGT Indicators (in or out of the aircraft).
- 8) Checks EGT system with engine removed from aircraft (in production line or overhaul shop).
- 9) Reads jet engine speed while the engine is running with a guaranteed accuracy of $\pm 0.1\%$ in the range of 0-110% RPM. Additionally, the TACAL circuit can be used to trouble shoot and isolate errors in the aircraft tachometer system.
- 10) JETCAL Analyzer enables engine adjustment to proper relationship between engine temperature and engine RPM for maximum thrust and efficiency during engine run (Tabbing or Mic'ing).

ALSO functionally checks aircraft Over-Heat Detectors and Wing Anti-Ice Systems (thermal switch and continuous wire) by using TEMPAL Probes. Rapid heat rise . . . 2 minutes to 800°F! Fast cycling time of thermal switches . . . 4 to 5 complete cycles per minute for bench checking in production.



Tests EGT System Accuracy to $\pm 4^\circ\text{C}$ at Test Temperature

(functionally, without running the engine)

Tests RPM Accuracy to 10 RPM in 10,000 RPM ($\pm 0.1\%$)

The JETCAL is in worldwide use . . . by the U. S. Navy and Air Force as well as by major aircraft and engine manufacturers. Write, wire or phone for complete information.

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The new
DM6

DAMPOMETER

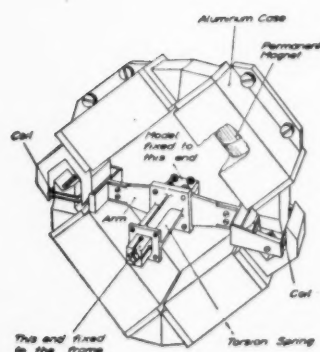
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USED for

- Wind tunnels
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- Structural panel testing
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Now also adaptable
to cock-release systems

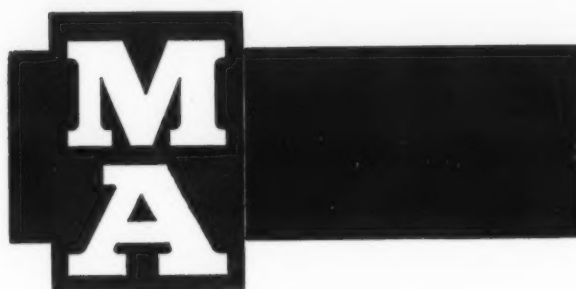
For literature and information
please write to

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In Canada: P. O. Box 222—Cardinal Heights, Ottawa, Ont.

For more information circle 5 on inquiry card.



Editor, MA:

The May-June 1957 issue of *MILITARY AUTOMATION* carries an article by Milton H. Aronson on Modern Digital Techniques. Described in this article and shown in Figs. 26 and 27 are memory devices involving quasi-random access.

Can you tell us who manufactures such devices or where we can get literature which will give us more information as to their operation and application?

John H. King, Bus. Mgr.
Westgate Laboratory, Inc.
Yellow Springs, Ohio

We are glad to provide additional information to satisfy the needs of our readers. The RAM Random Access Memory (Fig. 26) is a development of the Potter Instrument Company, 115 Cutter Mill Road, Great Neck, N. Y. and is manufactured by them. Fig. 27 illustrates the Tape DRUM, developed by the Brush Inst. Div. of the Clevite Corporation, 3405 Perkins Ave., Cleveland 14, Ohio. We believe these manufacturers will be pleased to answer your inquiries concerning their products. Another source for random-access memories is International Business Machines Corp., 590 Madison Ave., New York 22, N. Y.

Editor, MA:

It was a distinct thrill for all of us at Haloid who have had the chance to read the July-August issue of *MILITARY AUTOMATION* in which appeared the complete coverage on engineering drawings for the Armed Forces. Our compliments on its excellent preparation and presentation.

William N. Hesketh, Adv. Mgr.
The Haloid Company
Rochester 3, N. Y.

Editor, MA:

The Federal Civil Defense Administration has been studying the subject of shelters, both from the standpoint of designs and a national construction program, ever since its establishment by the Federal Civil Defense Act of 1950. We have recommended a comprehensive shelter plan for the nation which is now under intensive study by the executive branch of our government. As you no doubt realize, a national shelter program must be correlated with all other facets of national defense and it is presently being so considered. Whatever the decision may be, we feel confident that it will be in the best interests of the total defense of our nation.

Pending the completion of the national shelter construction study, this agency continues to recommend to industry, the general public and individuals the construction of blast and fallout shelters for their protection, according to vulnerability of location.

Although Public Law 920, the Federal Civil Defense Act of 1950, authorizes this agency to make contributions for the construction of shelters, no funds for this purpose have been appropriated by the Congress.

For your information there is enclosed a paper entitled, "Shelter for Schools." It is our earnest desire to stimulate the construction of shelters for school populations, but the criticality of funds for the growing classroom requirements tends to make it difficult for state and local governments to absorb the extra cost for shelters.

Benjamin C. Taylor
Director, Engineering Office
Technical Advisory Services

This letter serves to point up the problems your agency faces in attempting to "sell" a very important program. The paper "Shelter for Schools" (5-page mimeographed brochure FCDA BC 25398) contains design characteristics and estimates of shelter costs. A separate underground blast shelter is estimated to cost \$195 per person, of which \$45 would be fixed equipment. A separate underground fallout shelter would cost \$95 per person, of which \$15 would be fixed equipment. Fixed equipment includes filter units, emergency power, and sanitary facilities. A school basement designed to serve as a shelter is estimated to cost 10 to 20% more than a separate shelter of the same capacity. However, the brochure states, if the same space is also designed to serve regular school activities, only a portion of the cost need be charged to the shelter.

Editor, MA:

Just received your July-August issue and closeted myself barely long enough to cruise through its pages before my colleagues attempted to make off with the copy. Congratulations on this fine fourth issue. We look forward with increasing enthusiasm to each issue of *MA* and its informative feature articles.

Oakley L. Stockton, Major USAF
HQ 4620th Air Defense Wing
(Experimental SAGE)
Lincoln Laboratory, Lexington, Mass.

Editor, MA:

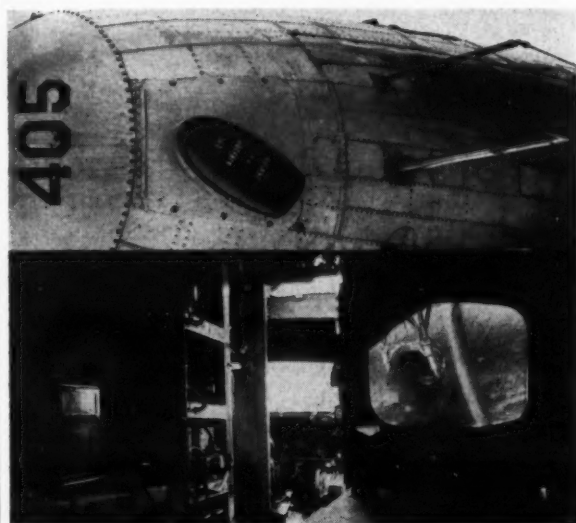
Many thanks for the tear sheets you sent on the story of the Armed Forces' handling of engineering drawings. Both myself and the folks at Filmsort feel your magazine did a beautiful job.

Lewis T. Bolger
Industrial Marketing
Services Co.
Sparta, N. J.

Airborne TV Road-Show

RUGGEDIZED, remote-controlled closed circuit TV equipment for use in airborne environmental testing and other techniques, will be demonstrated by a new-type Ground-Air Road Show presented in two phases by General Precision Laboratory, a subsidiary of the General Precision Equipment Corporation.

The first, or ground phase has been scheduled as follows: Cincinnati, Ohio—Oct. 21-22, Hotel Alms; Dayton, Ohio—Oct. 24-25, Dayton-Biltmore Hotel; Cleveland, Ohio—Oct. 28-29, Greenbriar Restaurant; Detroit, Mich.—Oct. 31-Nov. 1, Centerline Recreation Center; Pittsburgh, Pa.—Nov. 6-7, Penn-Lincoln Hotel.



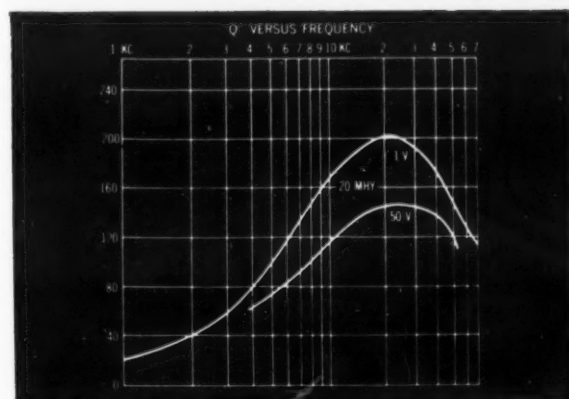
Faired-in TV camera monitors landing gear (Upper view) Inaccessible region is studied in safety on TV screen mounted inside plane cabin. (Lower view)

Operating equipment such as a TV projection system for viewing by large groups, a ruggedized TV camera for use in high vibration and noise environments, the new GPL three-lens turret camera with remote control and other standard closed-circuit television equipment will be demonstrated.

Persons contacted during the ground phase who have definite interest in the air-borne applications may make specific appointments at that time to visit and view GPL's closed-circuit television-equipped aircraft (here illustrated in landing gear study) which will tour the same territory at later dates to be announced.

For more information on GPL Closed-Circuit TV circle 209 on inquiry card.

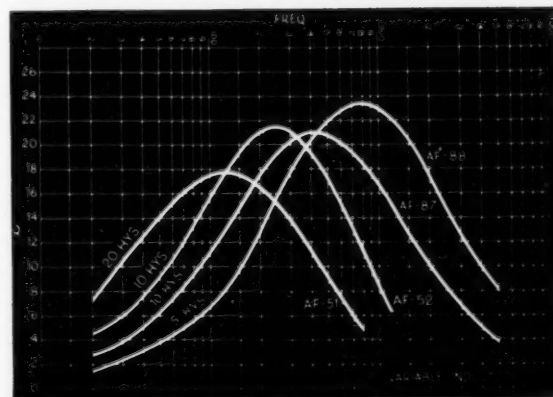
variable "L" by BURNELL



Typical Q vs. frequency characteristics of AT-10.

RANGE OF INDUCTANCES FOR STOCK ADJUSTOROIDS									
IND HY	AT-11	AT-12	AT-0	AT-6	AT-10	AT-4	AT-1	AT-15	AT-2
	TC-11 CORE	TC-12 CORE	TC-0 CORE	TC-6 CORE	TC-10 CORE	TC-4 CORE	TC-1 CORE	TC-15 CORE	TC-2 CORE
0.50									
500									
750									
1.0									
2.0									
3									
5									
10									
15									
30									
80									
100									
125									

For nominal D. C. R. values refer to Burnell catalog No. 103.



Typical Q vs. frequency characteristics of Variable Inductors.

ADJUSTOROID[®]

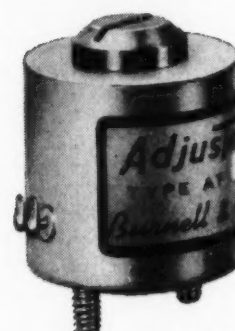
The Adjustoroid, a low cost adjustable toroid, exclusively developed by Burnell & Company, Inc., contains an actual complete toroid which relays all the excellent characteristics of the non-adjustable types. Adjustment is obtained by a completely stepless function with magnetic biasing.

The nominal inductance value for an Adjustoroid is the maximum value, and the inductance range is the nominal value minus approximately 10%.

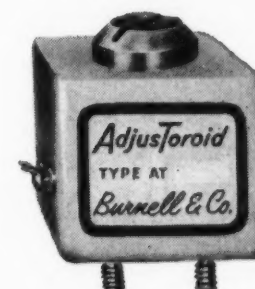
Hermetically sealed to meet Government MIL specifications. Many types of networks in tuned circuits are being produced which employ the Adjustoroid in completely hermetically sealed packages.

Intermediate inductance values as well as special taps and extra windings available on special order with minimum delay.

For additional technical data on Adjustoroids, refer to equivalent toroid in catalog.



AT-0, AT-6, AT-10, AT-4



AT-1, AT-2, AT-11, AT-12

ADJUSTOROID & VARIABLE INDUCTOR DIMENSION CHART

	LENGTH/DIA	WIDTH	HEIGHT
AT-0, AT-6	1-1/16"		1"
AT-10, AT-4	1-19/64"		1-1/4"
AT-15	1-31/32"		1-7/8"
AT-11, AT-12	45/64"	45/64"	3/4"
AT-1	1-3/4"	1-3/4"	1-1/4"
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AF-51, AF-52	1-19/64"		9"

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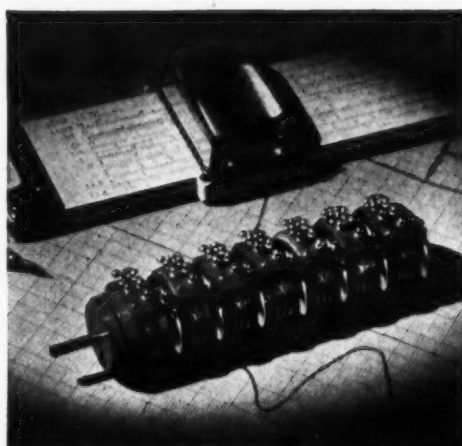
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November 5-6

Joint Military Industry Guided Missile Reliability Symposium, Naval Air Missile Test Center, Pt. Mugu, Calif. Commander, USNAM-TC, Reliability Symposium, Code CEN-1, U. S. Naval Air Missile Test Center, Point Mugu, Calif. (SECRET Security clearance and previous arrangements are necessary)

November 6-7

Third National Aero-Com Symposium (IRE) Hotel Utica, Utica, N. Y. Write R. C. Benoit, 138 Riverview Pkwy, Rome, N. Y.

November 11

Society of Plastics Engineers, Regional Conference on Plastics for Airborne Electronics, Ambassador Hotel, Los Angeles. Write Jack G. Fuller, Hercules Powder Co., 3460 Wilshire Blvd., Los Angeles 5, Calif.

November 11-13

Third IRE Instrumentation Conference, Professional Group on Inst., and Atlanta section IRE, Atlanta Biltmore Hotel, Atlanta, Ga.

November 11-13

Radio-Electronics-Television Mfg. Assn. Fall meeting, King Edward Hotel, Toronto, Canada. Write J. A. Caffiaux, 650 Salmon Tower, 11 West 42nd St., New York 36, N. Y.

November 13-14

Mid-American Electronics Convention (IRE) Mun. Auditorium, Kansas City, Mo. Write MAECON, 5109 Cherry St., Kansas City 10, Mo.

November 13-15

39th Annual Mtg. American Standards Assn. St. Francis Hotel, San Francisco. Write J. A. Caffiaux, Eng. Dept. RETMA, 11 West 42nd St., New York 36, N. Y.

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November 15-16

New England Radio Electronic Mtg. (IRE) Mechanics Hall, Boston. Write Samuel B. Fishbein, Boston Section IRE, 73 Tremont St., Boston 8, Mass.

November 16-21

International Conf. in Scientific Information Mayflower Hotel, Washington, D. C. Write Exec. Sec., ICSI, National Acad. of Sciences, 2101 Constitution Ave., Washington 25, D. C.

December 1-6

American Soc. of Mechanical Engineers Hotels Statler and Sheraton-McAlpin, New York. Write L. S. Denegar, ASME, 29 West 29th St., New York, N. Y.

December 3-4

Joint Symposium IRE Prof. Group on Mil. Electronics and Human Factors Soc. of America, Penn-Sherwood Hotel Philadelphia. Write Conrad Fowler, American Electronic Labs., 121 No. 7th St., Philadelphia, Pa.

December 6-7

American Rocket Society. Eastern Reg. Conf., Hotel Statler, New York. Write Mario W. Cardullo, Pres. Polytechnic Chapter, ARS, Polytechnic Institute of Brooklyn, 99 Livingston St., Brooklyn 1, N. Y.

December 9-12

Eastern Joint Computer Conference & Exhibit, Sheraton-Park Hotel, Washington, D. C. Write Margaret R. Fox, Nat. Bur of Standards, Washington 25, D. C.

June 9-13, 1958

Fourth International Automation Congress & Exposition and First Military Automation Exposition, Coliseum, New York. For information write to Richard Rimbach Associates, 845 Ridge Ave., Pittsburgh 12, Pa.

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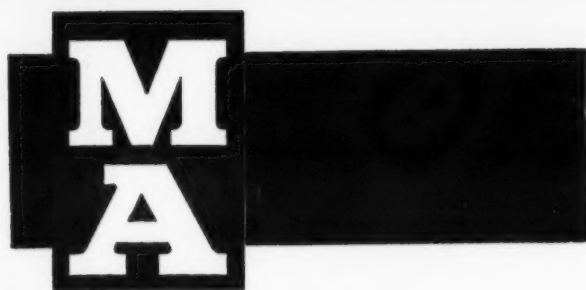
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GENERAL ELECTRIC

For more information circle 8 on inquiry card.



NAVY DAY 26 Oct. 1942

IN OUR picture the Battle of the Santa Cruz Islands October 26, 1942, is at a climax. The USS HORNET (CV-8) is shown underway, but blazing from the impact of a Kamikaze plane which had just buried itself in her flight deck. A few moments later the HORNET was stopped dead in the water by the explosion of a Japanese torpedo in her engine room.

Your editor has some vivid memories of this moment, because he was then on duty in the radar room of the HORNET. Our best radar was one of the NRL-built CXAM radars which had been salvaged from the USS CALIFORNIA, sunk at her berth December 7, 1941. Its bedspring antenna is visible on the mainmast.

What happened to the HORNET? She was sunk by our own guns to keep her from falling into Japanese hands, although she was in towable condition. Our ships were too greatly outnumbered to defend her. This left only one carrier, the ENTERPRISE, in the South Pacific, and she was too badly damaged to launch planes.

This historic picture always reminds the writer of the narrow margin by which we won the war in the Pacific. Our production and use of electronic equipment and automatic controls did much to turn the tide in our favor. One lesson that we learned the hard way is that it always takes a long time between a successful test model and the effective operational use of new instruments of warfare. During the Battle of

Midway, June 1942, we sent our HORNET Torpedo Squadron 8 in a sacrificial attack against the Japanese carriers. All the planes were lost, as were their crews, except for one pilot, Ensign Gay, who brought back the story of their heroic mission. Our slow TBD bombers had been unable to avoid either the enemy planes or the Japanese guns, but had lumbered straight in to deliver their torpedoes, some of which found their mark. A few weeks later a replacement squadron with new, fast, armored TBF's had reported aboard. What a difference those new planes would have made if our shipmates had had them in time!

On the other side of the picture, Japanese sailors have told in their memoirs how they were handicapped in operating without radar against the relatively well-equipped U. S. Navy.

Also, the proximity fuzed shell, airborne radar, night-fighter radar, and radar-controlled anti-aircraft guns were other new devices which we used with increasing effectiveness toward the end of the war. The Japanese tried in vain to counterbalance their lack of instruments with increased fervor of their Kamikaze attacks. Like our buddies in Torpedo 8, they learned it takes a bitter lot of lives to make up for a deficiency in materiel.

Another important lesson from World War II is that there is always a lag in the tactical application of new instruments of warfare. This explains in part why the radar warning at Pearl Harbor went un-

heeded; and why, in the First Battle of Savo Island our ships illuminated with star shells instead of relying on their fire-control radar. In time of peace, realistic maneuvers are the only practical way for commanders to gain experience in the direction and deployment of forces. Ships must go to sea, planes must take the air, and troops must go on field maneuvers.

We are told that probably never again will our industry have an opportunity to "tool up" to produce the weapons we need after hostilities have begun; that we must fight the next war with the weapons and with the fighters we have in trained readiness on the day our opponent decides the time is ripe for war. We are encouraged by official reports that we do not seriously trail the Russians in the development of a long range missile, and that a counter-measure for the ICBM is now considered feasible. Development must go ahead on both these frontiers. However, it is also important to remember that only those instruments and weapons in the hands of trained men who are directed by commanders competently schooled in the new tactics, will count in the day of testing. In short, a balance between a ready force and rapid development is necessary. We can be caught short if we neglect either.

Furthermore, let's not have any nonsense about not being able to afford the tools and men for our defense. The alternative cost, come Navy Day 1959 or Armed Forces Day 1960, may be a burning continent instead of a burning carrier.

Heard and Seen on the ANTIETAM

The electronic maintenance officer aboard the ANTIETAM is LTJG F. L. Bradshaw, USN, recently commissioned from Warrant rank, who has over 13 years experience in naval electronics maintenance. He exhibited a justifiable pride in his ship and her equipment and said that he had found that maintenance outages could be noticeably reduced by continuous operation. Instead of turning equipment off when not in use, he leaves it in stand-by operation with tubes lit. High power is not applied to the plates of transmitters, but receivers are turned full on with volume low. Brilliance controls on radar scopes are dimmed. Mr. Bradshaw cited the instance of a small home amplifier system he has operated continuously without tube or component failure for 10 years.

A 5J26 magnetron was recently removed from the ANTIETAM's air-search radar, failing after 5960 hours continuous operation. This compares with its average life expectancy on 900 to 1300 operating hours. The policy of "let the gear run" is recommended by BuShips.

When asked about mutual interference and noise problems aboard ship he pointed to bonds connecting



EDITOR MORRISON personally expresses his appreciation to **CAPT Wm. A. Thorn, USN**, for hospitality shown by all-hands of the **U. S. S. ANTIETAM** to the press during the **ACLS** sea trials. (Courtesy U. S. Navy)

the cable shielding at all equipments, which he had installed at the beginning of his tour aboard the **ANTIETAM**. He admitted that it was a shotgun remedy, but said that the noise level and mutual interference was negligible since it had been done.

Another source of pride to the electronics maintenance division is their color television system. They have 3 color TV receivers and 4 black-and-white sets for the crew's entertainment, all working off a single antenna system, engineered and installed by the electronics division. It is believed that the **ANTIETAM** is the first ship in the Navy to have color television.

Trends in Electronics Design

Mr. John Loeb, Bu Ships engineer in charge of the **ACLS** development, commented on reliability: "New equipments, such as computers, having ten times as many tubes as older equipments require elements with 10 times better order of reliability. Perhaps transistorization of computer circuits is the answer."

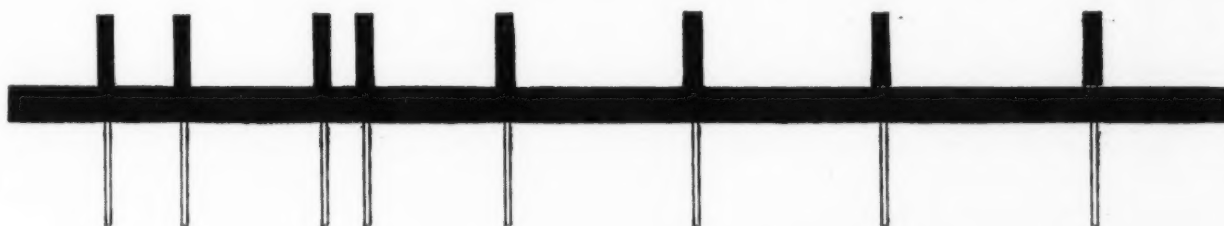
On the state of transistor circuit design: "Transistor manufacture has not yet been standardized. The new specification **MIL-T-19500A** should help designers by freezing and standardizing certain characteristics and designations so that equipment designed for a particular transistor application will not be left an 'orphan' by the time the equipment is in production."

Also, "We need more engineers who are experts in transistor circuitry. Experience in tube circuit design does not automatically translate into ability in transistor circuits. Many things are possible with transistors that cannot be done with tubes, and vice-versa."

On the state of magnetic amplifier design: "For many years manufacturers have not been able to reproduce the characteristics of the magnetic elements sufficiently near a standard to permit the replacement of a single magnetic unit. Hence, instead of replacing a transformer, matched sets of all components were needed as spares. Present magnetics are more uniform and permit the design of amplifiers which can be supported with a normal spares allowance."



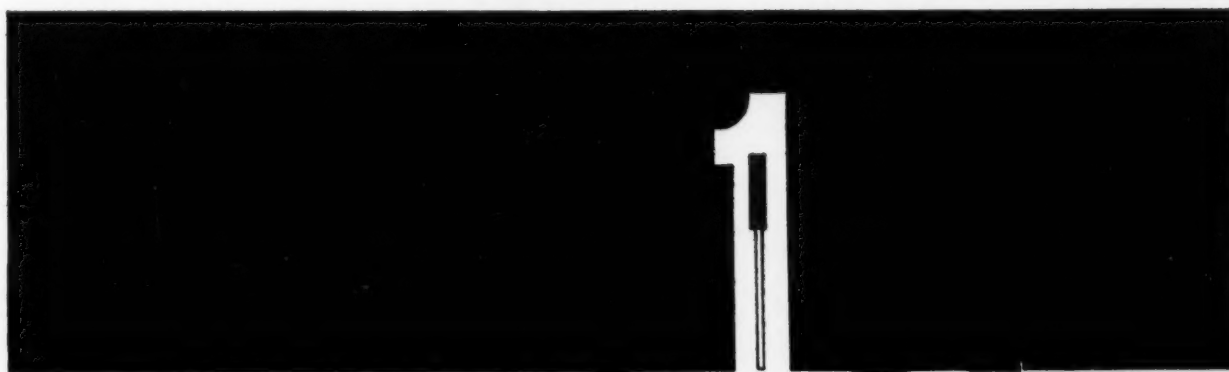
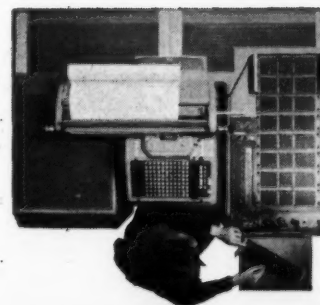
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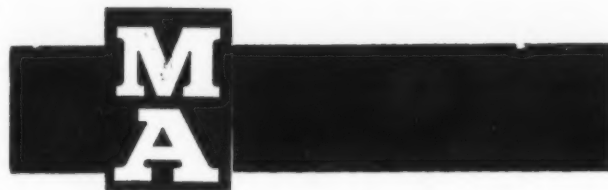
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The purpose of these short biographical sketches is to provide our readers with an insight into the lives of some of the military and scientific leaders now guiding the development of automation for the U. S. Armed Forces. This month we are happy to introduce Mr. Ira Kamen, Vice President in charge of Electronics for the General Bronze Corporation, Garden City, N. Y.

In 1952, at the age of 31, Mr. Ira Kamen, Chief Electronics Engineer for the General Bronze Corporation, was stricken with poliomyelitis. While at the Joint Disease Hospital, New York City, he perfected six new antenna designs, ran the hospital's electronics lab, and transacted over \$1,000,000 in electronic equipment deals for General Bronze from his hospital bed.

Today Mr. Kamen is vice-president in charge of the Electronics Division of the General Bronze Corporation. Although his illness of two years left him with crutches and a wheel chair, the 6-foot 210-lb former athlete has lost none of his drive, enthusiasm, or smiling approach to friends and business associates.

Mr. Kamen is responsible for new developments in the fields of radar, communications, missile guidance, aircraft antennas and electronic systems. Some of the projects in which he has been involved include:

- (1) The award-winning "DEW-line" feed and horn, which Western Electric, prime contractor for "Dew-line," calls "a milestone in electronic history." (See Lit-Bit next page)
- (2) A new mercury-pool-type rotary radar joint that enables using double the previous power.
- (3) A bipolarized feed system that doubles the usefulness of present antennas; also new, large and better designs for large antennas for anti-ICBM, scat-



IRA KAMEN

ter communications, radio telescopes and radar (all too highly classified to describe).

Mr. Kamen has written six important electronic texts and over 150 major engineering and trade articles. He has over 25 patents and patent applications. His coaxial-coupling-device patents form the heart of the RCA Antennaplex system and showed the way for all the successful multiple-antenna systems throughout the country.

During World War II, the young electronics expert served as a supervising professional radio engineer for the U. S. Navy. He was twice cited for outstanding accomplishments in the performance of his duties.

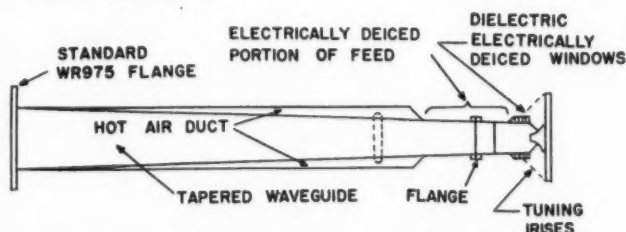
He studied electrical engineering at the College of the City of New York and successfully completed graduate work in UHF technique and industrial electronics at the College of Engineering, New York University.

Mr. Kamen lives with his wife, Erna, and young son, Jeff, 13, in a lovely ranch house in East Hills, Long Island.

His hobbies include activity as a ham radio operator and writing electronic texts. Included in his works are "TV-FM Antenna Installations," "TV and Electronics as a Career," "Television Master Antenna Systems," "Pay as You See TV," and "Scatter Propagation, in Theory and Practice."

DEW Line Antenna Feed

Various shapes of horns were investigated in an anechoic chamber by placing the effective radiation center at the axis of rotation of the pickup horn. Only E- and H-plane patterns were measured. With the completion of the primary patterns of the first horn it became evident that the size of the primary radiating apertures of the feed had to be much smaller than those indicated by calculations. This is probably a result of the interaction of the primary radiation with metallic walls of the waveguide feed and specifically reflection effects which superimpose the image of the aperture from the metallic wall of the feed to the direct radiation of the aperture. The proper E plane aperture was achieved in two additional steps. The H plane pattern presented more difficulty. With an F/D ratio of 0.3 the angle subtended by the reflector is 159° . The space attenuation factor is 4.5 db which, for a 10 db edge illumination provided by the specification, would allow only 5.5 db taper at 80° away from the center. Devices such as the incorporation of a metallic post across the aperture of each horn were tested and found effective but the impedance mismatch introduced was intolerable for the strict VSWR specification. It was found, however, that if the corners of the horns were cut, the primary-H pattern was sufficiently broadened without considerable mismatch.



The present design offers a wide bandwidth about 25% with a VSWR below 1.2, an efficiency of 60.3% and side lobes of the order of 23 db.

These characteristics are very desirable for military and commercial link applications. In the case of intercontinental scatter relay systems the ability to transmit many channels over the same beam may be the deciding factor for making intercontinental television economically feasible.

The low value of VSWR is very important especially in television and teletype work where, because of the unusual high mismatch between the generator and transmission line, a good part of the reflected power will be re-reflected at the generator and will be incoherently transmitted, adding to the effective noise of the system. Therefore the success of the future of scatter links for commercial application is greatly dependent upon antenna systems of low VSWR over large range of frequencies. (From new 11-page lecture to the New York I.R.E. by Mr. Doundoulakis, Electronics Research, General Bronze Corp., 711 Stewart Ave., Garden City, New York)

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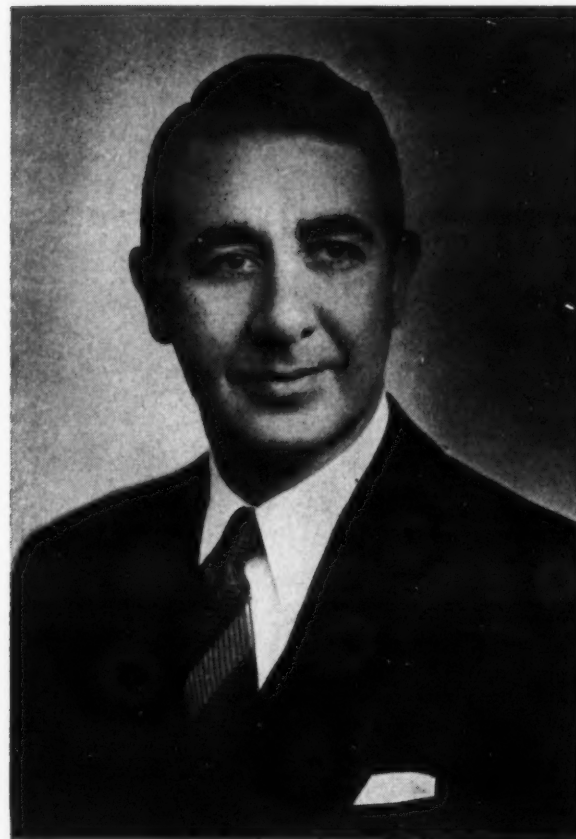
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Wilson Heads Daystrom Avionics



DAYSTROM, INC. has announced that Mr. Richard A. Wilson will head its new Avionics Group, which is a working organization of certain Daystrom subsidiaries for development and manufacture of complete electronic systems for the guidance and control of missiles and aircraft.

Involved are Daystrom Pacific Corp. (which manufactures gyroscopes, potentiometers and other miniature electronic equipment), Daystrom Transicoil Corp. (servo mechanisms), Daystrom Instrument Division (electronic computer equipment and precision sub-assemblies), the Aircraft Instruments Div., of Weston Electrical Instrument Corp. (specialized equipment), and special research and development facilities at Poughkeepsie, N. Y. The Avionics Group will be administered from the corporate offices of Daystrom, Inc., at Murray Hill, N. J.

Mr. Thomas Roy Jones, president of Daystrom, Inc., states that "Up to the present, each operating unit has operated individually, producing equipment and assemblies for avionics and other uses. Through consolidation we will be in a position to coordinate all needed facilities into a single group for the development and



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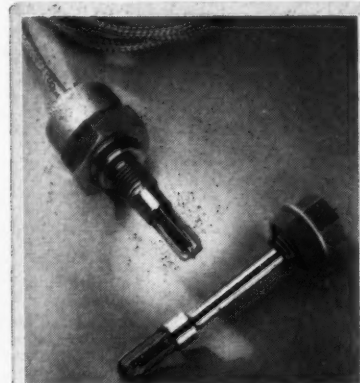
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TRANS-SONICS INCORPORATED

BURLINGTON, MASSACHUSETTS

manufacture of entire guidance and control systems. This step falls in line with the current trend to utilize contractors who can do a complete job in the military field, whereas, in the past, the government bought instruments and took the responsibility to see that they were properly integrated in the equipment for which they were designed."

Mr. Wilson is known throughout the Armed Services for his work on military contracts and the building of a successful sales, engineering and manufacturing team for precision, complicated electronic systems.

In addition to his responsibilities as the head of the newly formed Avionics Group, Mr. Wilson has been named a vice president of Daystrom, Inc., in charge of their activities in weapons systems, underwater equipment, and certain other military and industrial work of the company's operating units.

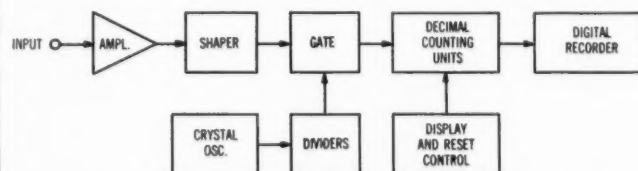
Mr. Wilson was born in Boston, Mass., and is a graduate of Lowell Institute at M.I.T., where he studied electrical engineering.

For more information on Daystrom Avionics circle 210 on inquiry card.

EPUT Techniques

Measurement of radio frequencies by digital counting of r-f cycles per unit time is an entirely suitable method.

The time during which the gate is open (the sampling period) is known and accurately controlled by reference to a crystal oscillator (see Fig.). For even greater convenience Berkeley offers an automatic read-out accessory which provides a printed record of each reading. This facility for unattended operation has obvious advantages in heat cycle or other routine fre-

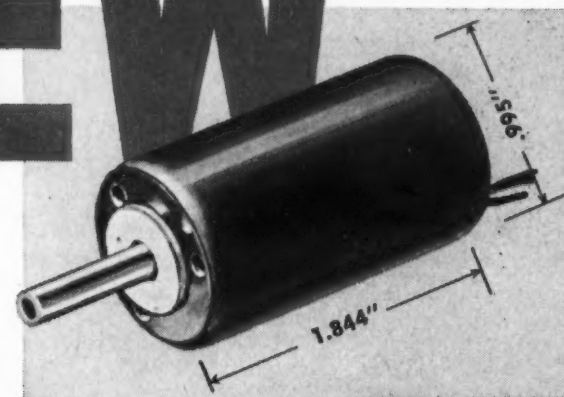


Events-Per-Unit-Time Meter for Measurement of Medium Frequencies.

quency stability checks. Most of these instruments offer such advanced features as: (1) Precisely regulated crystal reference oscillators capable of standardization against WWV. (2) Ac-dc input coupling with step attenuators and adjustable trigger level controls for noise discrimination. (3) Frequency dividers stable for long period of time and over wide variations in ambient temperature and line voltage. (4) Provision for control from an external frequency standard. (5) Precise time marker output pulses from the time base dividers. (From new 18-page Data File 111, Beckman/Berkeley, Dept. 7244, 2200 Wright Ave., Richmond 3, Calif.)

For this literature circle 102 on inquiry card.

NEW



EAD's 1" MOTOR

Operates Directly Off the 115 volt, 60 cycle Line!

...no step-down transformers, no dropping resistors necessary!

NOW—for the first time, a miniature, precision motor that operates from a 115 volt, 60 cycle line—directly! And this new EAD unit offers higher performance and higher capacities than other 1-inch diameter motors.

Typical stall torque is 0.7 ounce-inches—no problem starting in cold temperatures—with a running torque of 0.4 ounce-inches. Packed with power and precision, EAD's motor gets more air from bigger fans! For example, it easily drives a 3" fan blade at 3200 rpm. It drives a 4" fan blade at 2700 rpm with only 6 watts input.

Whatever the application, as a fan or blower drive or general purpose induction drive motor, if you want high-output, longer life, a precision, power-packed miniature to do a dependable job, your answer is this new EAD 1-inch motor. It has much more to offer in your vital applications.

TYPICAL SPEED-TORQUE CHARACTERISTICS	
SPEED RPM	TORQUE OUNCE-INCH
3500	0
2900	.50
2500	.75
2000	.95
0	.74

**Precision,
Performance,
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**Get All 3
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WRITE FOR MORE
INFORMATION TODAY!



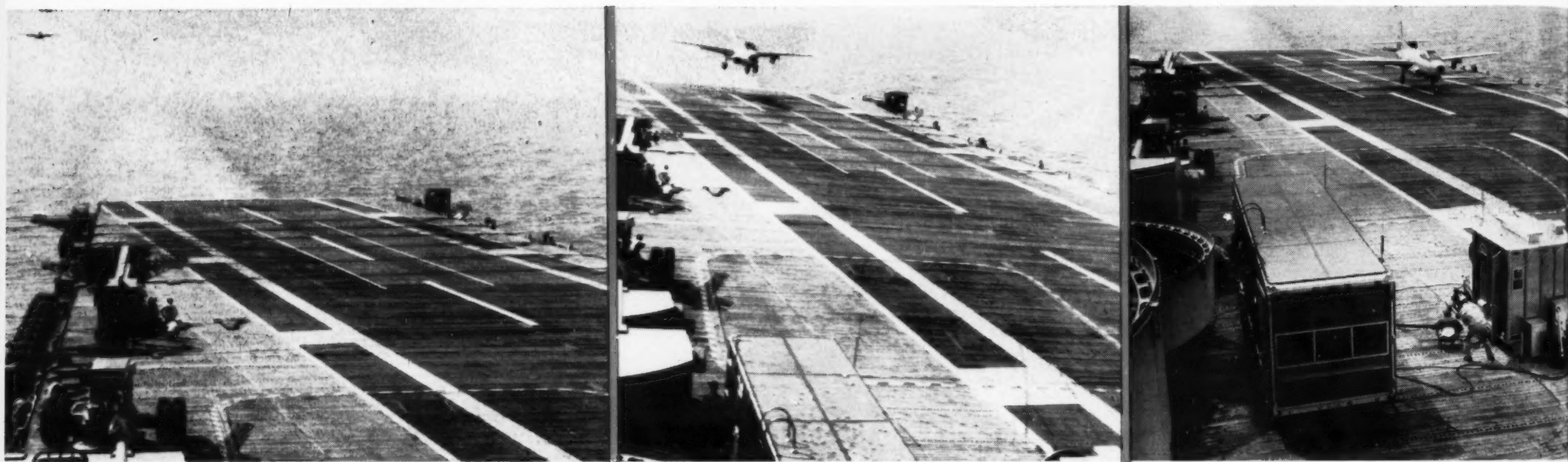
345 Central Ave., Dover, New Hampshire

For more information circle 15 on inquiry card.

For more information circle 14 on inquiry card.

September-October, 1957

AUTOMATIC CARRIER LANDING SYSTEM PASSES SEA TEST



NEW SYSTEM REPEATEDLY DEMONSTRATES ability to land F3D Skyknight without pilot's aid aboard USS ANTIETAM in Gulf of Mexico. Landing system gear in foreground trailers may outmode Landing Signal Officer (port side fantail), will be used with Optical Glide Path System (starboard flight deck aft).

JET AIRCRAFT landings aboard a carrier under adverse conditions of visibility and ship motion have been demonstrated in sea trials conducted approximately sixty miles south of NAS Pensacola, Fla., by the Naval Air Test Center, Patuxent, aboard the USS ANTIETAM (CVS-36), Capt. Wm. A. Thorn USN, Commanding. These trials were followed by additional carrier tests in September to establish operational parameters for a prototype carrier model, the AN/SPN-10.

The Automatic Carrier Landing System is a development of the Bell Aircraft Corporation, of Buffalo, N. Y., under a contract with the Navy Bureau of Ships. An Automatic Ground Landing System is also being developed by Bell Aircraft for the Air Force and is designated the AN/GSN-5. Although it need not compensate for ship's motion, the ground-based version must solve other peculiar

problems, including roll-out guidance for planes on the ground. Using a minimum of airborne components, the system can be used also to guide commercial and private aircraft to safe touchdown.

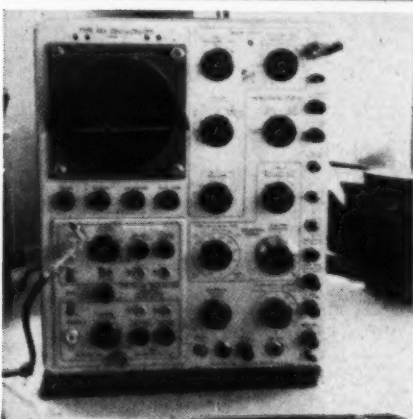
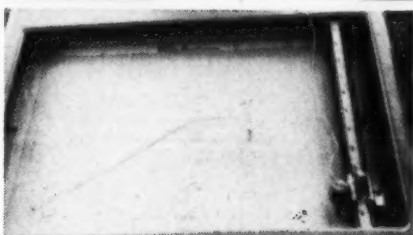
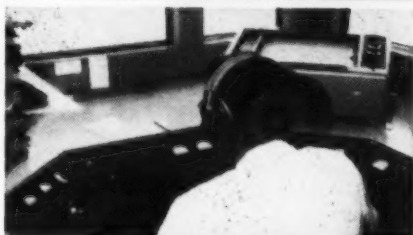
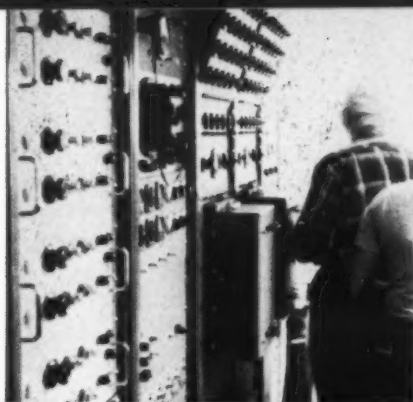
Heart of the system is (1) an extremely accurate K-band radar which continuously reports the position of the plane after "lock-on" approximately three miles behind the carrier's fantail, (2) a data stabilization unit, (3) a radar antenna drive system, and (4) a REAC computer. Items 2, 3 and 4 were supplied by the Reeves Instrument Corporation, a subsidiary of Dynamics Corporation of America.

Jets Hit Angled Decks Under Power

With the advent of heavy jet planes, which land at speeds above 100 knots, the failure to engage or to hold an arresting cable often meant a major wreck on the flight deck, which invariably damaged the

landing plane and usually its pilot and several parked planes. This hazard threatened the end of the aircraft carrier until the development of the angled flight deck which permits jet landings under power. No barriers are used now and if a pilot does not make the correct approach he is waved off for another pass. Also, if the hook fails to engage or pulls out, the plane usually has sufficient speed to regain the air. If not, loss of a single plane and a usually harmless dunking for the pilot is the worst that happens.

However, high jet landing speeds make the jobs of the LSO and the pilot making an approach considerably more difficult. When visibility is good, Carrier Controlled Approach radar (CCA), the shipbased equivalent of Ground Controlled Approach (GCA) equipment, enables the planes to be vectored into the proper position for beginning the landing



TRAILER INSTRUMENTATION
(Top to Bottom) REAC computer; landing control console; altitude-range plotter shows approaches from different altitudes brought into identical approach lane; pip on step of scope shows F3D is "gated".

OPTICAL GLIDE PATH MIRROR, CCA radar antenna, and ACL'S trailers as seen from the fantail.

approach. Then the Optical Glide Path Indicator (see P. 132 May-June MILITARY AUTOMATION) enables the pilot to guide himself into a good landing by maneuvering his plane so as to keep the "meatball" centered in a landing mirror, which is stabilized for ship motion.

Zero-zero Landings for Any Type Plane

Visibility of one mile and 300 feet above deck is the minimum needed to use the mirror landing system or to make a safe CCA and LSO assisted landing. Bad weather frequently precludes this minimum, even in daytime. The new ACL System permits, for the first time, carrier landings in zero-zero visibility. The flight-path computer can provide control patterns to fit any type of plane or desired approach. Any plane equipped with an autopilot and a data-link transceiver, both planned standard carrier-plane equipment, can be landed automatically by this system, which provides rudder, aileron and elevator signals to the plane, as well as a "locked-on" signal from pilot to carrier. (It would be possible also to include landing-flap and wheels-down control if desired.) The F3D used in the trials has been equipped with an automatic air speed control which holds the approach and landing speed constant at the value the pilot has selected. Air speed can be pilot controlled if the plane is not so equipped.

ILS crossed-pointer signals can be transmitted by the ACLS to guide the pilot of any plane not equipped with an auto-pilot and data link.

A poor attitude of the plane, any radical change in command from the system that might be caused by an equipment failure, or a sudden yaw of the carrier, will initiate an automatic wave-off. Also the Automatic Landing System controls can be overridden by the pilot at any time. The glidepath mirror provides assurance that all is going well.

Mr. Leston P. Faneuf, president and general manager of Bell Aircraft Corporation, who witnessed the trials from the bridge of the ANTIETAM, stated that this system was an outgrowth of their work in REGULUS missile recovery, and that they conducted numerous shipboard studies of ship motion to de-

termine its effect on the landing operation. These studies are classified by the Navy.

Trailer Installation Facilitates Development Tests

Installation of the test system aboard the carrier was simplified by incorporating the radar, data stabilization unit and stable elements in one trailer, while the radio data link, REAC computer, and the extensive monitoring equipment necessary for documenting test results were housed in a second trailer. Mr. John Loeb, BuShip's engineer in charge of the development, indicated that any shipboard production model would require much less space and equipment. The radar antenna would be a fixed installation on the island, with all test-monitor and recording equipment eliminated. He said the REAC computer, which was used in its standard form to provide maximum latitude and instrument amplifier channels in test and development, had been found to provide many more functions than were required by all types of plane approach patterns, and that a simplified unit would suffice for the production model. Estimates given on the probable date at which the development might be installed on ships were from two to four years, depending on the international situation and availability of appropriations.

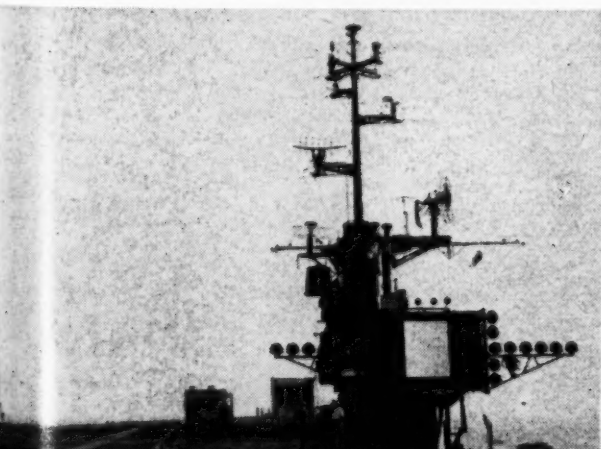
Pilots Welcome Automatic Aid

Automatic Carrier Landing is termed "The most exciting development I have witnessed in Naval Aviation," by CDR Don Walker, USN, veteran Patuxent Center test pilot. CDR Walker repeatedly demonstrated his confidence in the Automatic Landing System by making arrested landings with both hands resting on his helmet.

The mental hurdle of the final landing hazards have caused many pilots returning from a strike, with little fuel aboard and wounded or suffering from fatigue, to panic at the critical moment while making their approach. Small wonder that the pilots feel no resentment at the skill of this robot that brings them down safely. The salvage of a single Navy carrier jet, costing over \$300,000, will more than pay for one of the systems, not to mention the life and money value of an experienced pilot.

TEST PILOT CDR DON WALKER shows Editor Morrison his logbook with cockpit data on each approach.

FROM BRIDGE OF USS ANTIETAM, Captain William A. Thorn, USN, and Mr. Leston P. Faneuf, Pres. Bell Aircraft Corp., observe trials.



Russell and Sigurd Varian, chairman and vice chairman of Varian Associates' board of directors, are another famous brother team important in aviation history. Just 35 years after Wilbur and Orville Wright's historical flight, the world's first klystron tube, invented and developed by the Varian brothers, operated successfully, thereby prefacing an exciting new chapter in aircraft control through electronics. The following story by Dr. Russell H. Varian, written expressly for **MILITARY AUTOMATION**, is a complete first-hand statement about the original work in the development of the klystron.

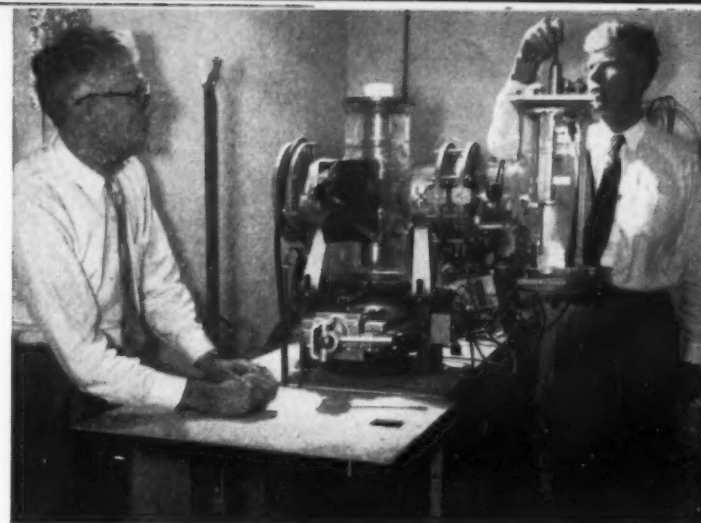


FIG. 1. THE VARIAN BROTHERS, Sigurd (left) and Russell (right) inspect experimental vacuum system in Varian Associates laboratory.

The *INVENTION* and *DEVELOPMENT* of The Klystron

Dr. RUSSELL H. VARIAN

THE ORIGIN of the klystron had its roots both in previous experience in television research and in activities in pure physics. From 1930 to 1933 I had been engaged in television research with Philo T. Farnsworth both in San Francisco and with Philco Corporation in Philadelphia. Previous to this time there had been an effort on the part of the faculty of the Stanford Physics Department to obtain a high voltage source of X-rays in the order of 2 million volts. This was prior to the financial crash of 1929. While money flowed rather easily at that time, it did not gush for scientific purposes and a budget of something like \$35,000, which was estimated to be the cost of using the Ryan High Voltage Laboratory to generate X-rays, was completely unobtainable.

During my experience in television work I became

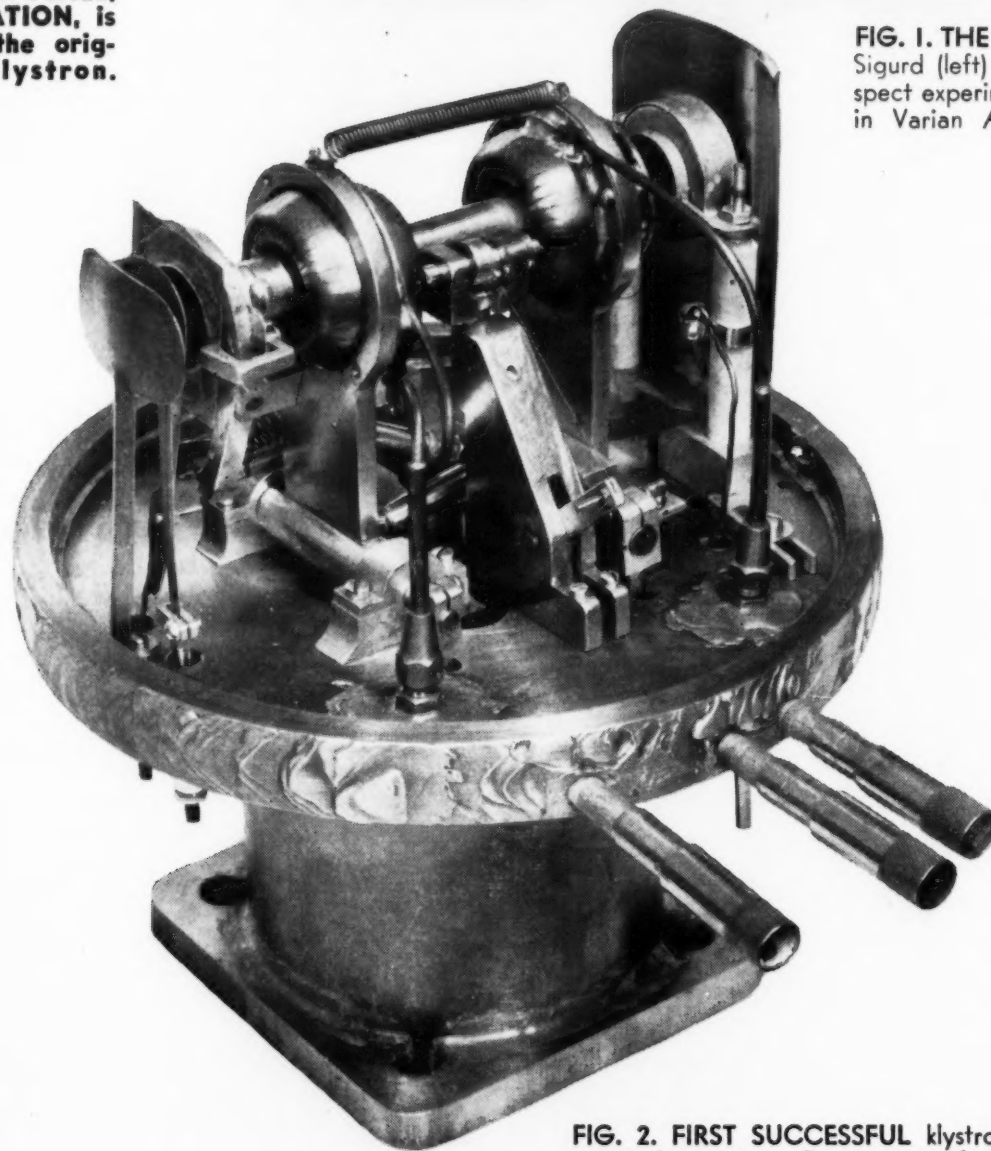


FIG. 2. FIRST SUCCESSFUL klystron incorporated ingenious fluorescent r-f detection feature, also invented by Dr. Varian. (Courtesy Microwave Laboratory Museum, Leland Stanford University.)

acquainted with the frequency limitations of the then existing vacuum tubes. The general belief at that time was that the external resonant circuits were the primary limitation on performance.

After 1933 I returned to Stanford to continue work for a doctor's degree in physics. Dr. W. W. Hansen and I took it upon ourselves to try to find a cheaper method of getting high voltage X-rays than the one previously proposed. We investigated a large number of schemes, all of which looked interesting but too expensive, and finally Dr. Hansen proposed to use a concentric line resonator. Then the question was raised as to whether the concentric line resonator was really the most efficient form of resonator that could be designed.

About the time we had reached this point my brother Sigurd, who was then a pilot for Pan American Company in the Western Division running between Brownsville, Texas and the Canal Zone, had come to the conclusion that he would put into effect a tentative plan that we had had for a long time to set up our own laboratory. We set up a very modest

Luftwaffe Inspired Radar

During the period of this work, Hitler's rapid rise to power took place and resulted in many discussions between my brother and myself concerning the great danger to the world in general. My brother had had a great deal of experience in blind flying with Pan American and was quite sure that he could locate a target and deliver a load of bombs either in bad weather or at night without giving the defenders even one shot at him by any of the existing defense methods. As time went on he became more and more alarmed about the striking power of Hitler's air force and this line of thought led naturally to ideas about what is now called radar, an aircraft locator that would be completely independent of visibility conditions.

As a physicist I knew that very short wave lengths would be required and the first major problem for providing such a defensive instrument was therefore, the production of the very short wave lengths or very high frequencies that were required to produce a satisfactory radar.

Our early thoughts on the subject of radar were, of course, guided by a knowledge of physical optics. The average radio man may know little about physical optics but it is something that every physicist is familiar with. As an example of how little knowledge of physical optics some radio people, and even patent examiners of years ago, had, I remember one patent that was cited against our application in which the applicant showed parabolic reflectors for reflecting beams of radio waves for locating airplanes using the wave lengths then available which were many times the diameter of the parabolic reflectors. To a person familiar with the principles of physical optics, it would be entirely obvious that such a system would form no beam at all.

Radar Patterned on Optics

The frequency required for radar was quite obvious to anyone familiar with physical optics because it had to be a wave length which was quite long com-

pared to the diameter of cloud particles or rain drops, and quite short compared to the diameter of beam focusing and projecting equipment of a practical size for use. This inescapably put the required frequencies for radar into the microwave region. Given a source of radiation of the right wave length, any physicist would conclude that a parabolic reflector or some directional array of similar characteristic would constitute a practical means for locating targets in azimuth and elevation. Practical methods of getting range were not quite so obvious. Our early thoughts in determining range did not depend on the transmission of short pulses and measurement of the time delay of the return signal. At this time we had not realized the possibility for getting enormously high instantaneous power for extremely short intervals of time separated by relatively long gaps of silence. Our early radars were based on the determination of the doppler frequency of a moving object by heterodyning a part of the transmitted signal against the reflected signal.

We conceived a method of determining range which consisted of transmitting three or more slightly different frequencies and heterodyning them against the same frequencies derived from the transmitter. This system was capable of giving range information by comparison of the phase angle between the doppler note from the different heterodyne receivers. This type of ranging equipment was never built because of the appearance of the short-pulse-type radar systems. While our system constituted a possible method of measuring range, it has the great disadvantage that if two moving targets are present in the beam at the same time, ranges will be indicated that are not the true range of either target.

During the time when my brother and I were working at Halcyon, Dr. Hansen was continuing his work at Stanford on the question of the most efficient form of resonator. We were in frequent correspondence both concerning his work in resonators and our work on the ruling engine. The final result of Dr. Hansen's work was to obtain mathematical solu-

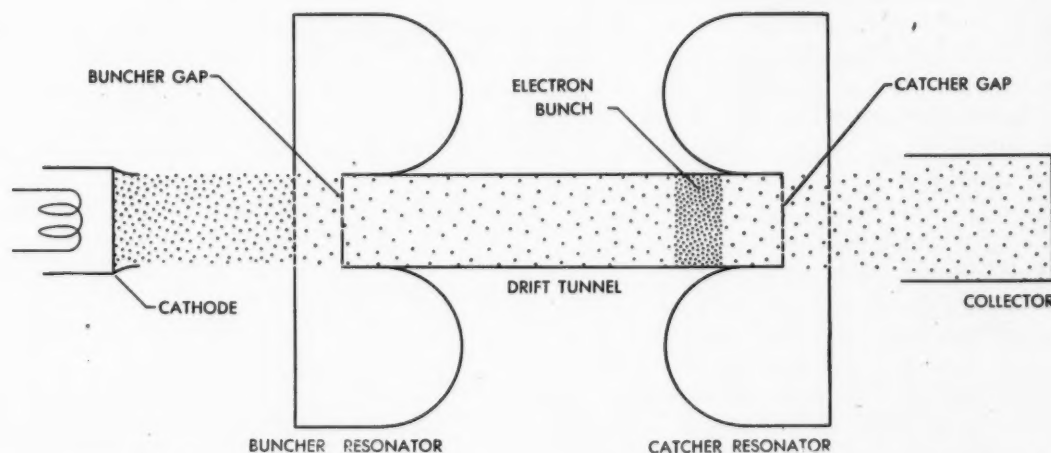


FIG. 4. PRINCIPLE of the klystron tube with two resonators. Electrons are produced by the cathode at left and accelerated toward collector at right. As they pass through the oscillating electric field of the first resonator, some of the electrons are speeded up and others

slowed down. As the electrons proceed down the drift tube, the faster ones catch up with the slower, forming a bunch. When the bunch passes the second resonator, an oscillation is excited in it.

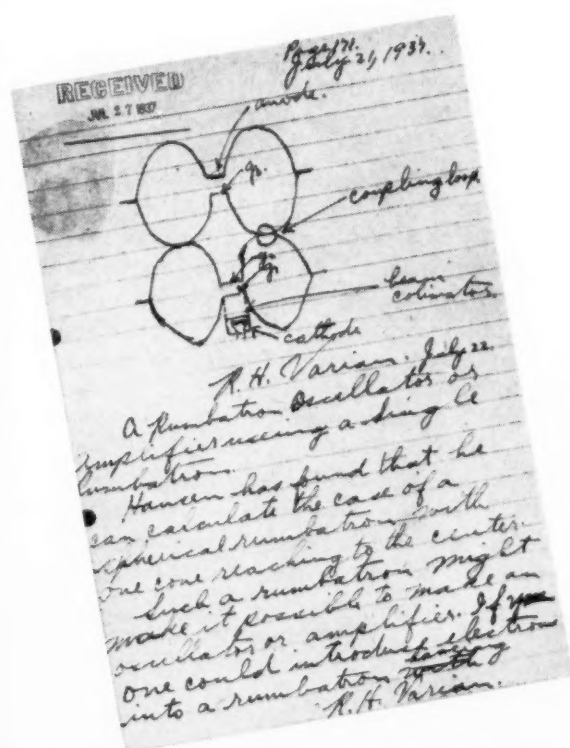


FIG. 3. PAGE from early notebook of Dr. Russell Varian. (Courtesy Sperry Gyroscope Co.)

laboratory at the old family home at Halcyon, California, and started on a project which we knew would provide a small steady income, if successful. This was to build a ruling engine to rule diffraction gratings. This was a mechanical problem that had never been satisfactorily solved. We worked for a considerable time on this project which proved to be much more difficult than at first anticipated.

tions for certain types of hollow resonators and to show that these were indeed much more efficient than the conventional types of concentric line resonators. My brother and I finally decided to abandon the ruling engine project and go to Stanford and start on the project of producing radar. I felt that Dr. Hansen's work was a good starting point for a high frequency source which could be used for radar.

Classification An Inventor's Tool

After long discussions with Dr. Hansen I became very much aware of the fact that the resonant circuit requirement which the hollow resonator could meet was only one of two necessary conditions to achieve the frequencies that we were interested in. The other was a means of eliminating the troubles caused by the flight time of electrons in the ordinary grid-control-type of vacuum tube. This second requirement apparently required a new type of current control in a vacuum tube. We spent many hours thinking of all the types of controls that could be used. We very early arrived at one definite conclusion—that the cavity resonator must itself provide the electron control and that the electron control must be of a new type.

One day, after we had thought of a number of schemes, I was occupied in developing a classification for all the schemes we had thought of so that we could systematically investigate them all and not discover later that we had overlooked some of the most promising ones. In the process of developing this classification I suddenly thought of the velocity-grouping principle (Fig. 4). From a psychological viewpoint it is rather interesting that this attempt at classification actually produced the invention of the klystron. The velocity-grouping principle did not fit any of the schemes of classification that I had contrived and I rather think that the idea occurred to me because I was unconsciously attempting to test the validity of my classifications. Hence I thought up an exception to the classification which actually turned out to be the basic concept of the klystron.

There followed a very extensive series of discussions between Hansen and myself about the applicability of this new idea. After the first few discussions we had pretty well concluded that this new idea was the best of any that we had conceived, and the remainder of the discussions were related to the means for carrying it out.

RF Detected by Fluorescence

In the meantime my brother was impatient and needing us all the time so that he could get into the work by actually building something. Less than two or three weeks after the original idea, we had settled on a design that looked very much like the early klystrons. After deciding what kind of an oscillator to build, there was another important problem—if we built such an oscillator, and if it oscillated at times, how were we going to know that it oscillated? The general character of the original klystron was a two-resonator device which required tuning of one resonator to the frequency of the other and oscillations would not occur unless this was accomplished. How were we to know when this was accomplished?



FIG. 5. THIS PHOTOGRAPH, taken in the Physics Dept. at Stanford University, shows the late Dr. W. W. Hansen just before the first linear accelerator operated for the first time. (Courtesy the San Francisco Examiner.)

None of the measuring instruments now available in the microwave region had been developed, and the only detectors we had that could be considered for the purpose were the old galena crystal detectors of early radio. We did not even know that these would function at all at microwave frequencies, and if they did function any meter that we could attach to them would be slow acting and the probability extremely high that we never would detect oscillations. I finally decided that we could allow a small part of the electron beam used to drive the klystron oscillator to pass through a hole in the last resonator and be deflected into the space beyond by a magnetic field so that it would land in a moderately small area on a fluorescent screen. This would provide a quick and sensitive detection system for any oscillations which occurred. As it turned out, this invention was probably about as important as the klystron invention itself, because without it we probably never would have discovered the oscillations although they would have been occasionally present. The first model we built produced some oscillations which my brother saw on the fluorescent screen, but the tuning mechanism was not capable of going smoothly through resonance and so we were never able to repeat the result. It was about the third model we built which gave reproducible evidence of oscillation (Fig. 2).

Promotion Moves Slowly

At the beginning of the series of experiments, the university had made an agreement with us and pro-

vided the facilities and stock of the machine shop, plus \$100 for purchased parts. At the time when we got conclusive proof that the klystron worked, we had spent about \$50 of this \$100 appropriation. This was probably the cheapest project ever completed in microwaves. About the time we had demonstrated the operability of the klystron, we had exhausted our own financial resources and very quickly had to hunt up some means of support. My brother made a trip to San Francisco and talked to people in all three branches of the military service. All three branches expressed mild interest in the idea but none showed signs of supplying support for further work at a near date. Sigurd also went and talked to the NACA office. They were interested, but were quite frank in saying that they had no one capable of making a judgment of the device. However, a few days later, we had a phone call from the CAA office and we found that a man in the CAA who was concerned with blind landing systems for airplanes had arrived and he was extremely interested in the idea. Also, there was a man from the Sperry Gyroscope Company at CAA who expressed interest in seeing the device and we were asked whether he could come along with the other men. We were somewhat afraid to disclose the device at this time to a commercial concern but we decided to take the risk since we had to have support rather quickly. The CAA people were quite sure they could get support for this project rather quickly and we were much encouraged. However, much government red tape intervened and it soon became apparent that although there was a great desire among some highly placed personnel in the CAA to support this project it would take a long time to get the money.

In the meantime, the Sperry Gyroscope Company saw in this device something that would supersede their military searchlights for air defense and therefore they offered to support the project. A klystron had been produced but it remained for others to complete the radar system we had contemplated. The project was supported for some time on the Pacific Coast by the Sperry Gyroscope Company but in the fall of 1940 they moved the whole operation to Garden City, Long Island, where we continued to develop the klystron and related equipment during the war.

British Make Rapid Development

When it became apparent that a new breakthrough had been made in the microwave field by the invention of the klystron, my brother and I, as well as the university, naturally were quite anxious to obtain publication. We wrote one letter to the Editor of the Journal of Applied Physics and later a more complete article by Drs. Hansen and Webster was published. We were a little uncertain about who would be helped most by these articles, but as later developments proved, the publication of these articles was a very important factor in winning the war since it was the British who immediately saw the significance and went to work under high pressure to produce klystrons. They had klystrons which were practical for operational use considerably before we in America had them and all of the earlier radars used by the American forces used klystrons which were copies

of British models. On the other hand, the Germans did little or nothing about developing the klystron.

During the war there was a great deal of development of the klystron under forced draft. The 2K25, which is still used extensively, was developed by Bell Laboratories and the Western Electric Company and manufactured principally by Raytheon Manufacturing Company. The Sperry Gyroscope Company built a good deal of the radar equipment and many laboratory klystrons and much measuring equipment, but never did get into any volume production on klystrons during the war. Production models were soon frozen and not changed radically during the war.

High-Power Klystrons

During the war, Dr. Hansen and I tried hard to get work going on high power klystrons but the decision had been made to use magnetrons as power sources and to use klystrons only as local oscillators for receivers. This may have been a wise decision from a production viewpoint during the war, but it left a conviction in the minds of many people that was very hard to break. Magnetrons were considered to be power sources and klystrons were regarded merely as local oscillators.

Immediately after the war, Sperry Gyroscope Company, under government contract, developed some successful medium high power klystrons but they did not find their way into systems.

After the war Dr. Hansen returned to his position at Stanford University and started the development of a linear accelerator of electrons (Fig. 5). In this he was reverting again to the old quest for high voltage electrons and X-rays only now armed with a new tool, the old ambition of 2 or 3 million volts had been raised to the billion volt level. The work on the linear accelerator was supported by the Office of Naval Research and later also by the AEC and is now functioning in the field of pure physics to further solve the mysteries of the nuclei of atoms.

A by-product of this research was the development of super-power klystrons. It took this project in pure physics to break down the concept that a klystron was nothing but a low-power local oscillator device. This project proved that klystrons are far from being limited to low power devices and are in fact capable of greater power than magnetrons had ever produced. Now klystrons have invaded the high power field and are extensively used in the Continental Defense system as well as other applications.

There are now a very large number of klystron types ranging in power from milliwatts to megawatts including both pulsed and CW types and ranging in frequency from around 200 megacycles to above 30,000 megacycles, many of them available as production models. After many fluctuations in interest and arguments as to applicability the klystron has found its place as an accepted component in both military and commercial apparatus.

* * * * *

Articles to follow in this series will include a survey of modern Klystron tubes and applications, also tutorial articles on travelling wave tubes and backward wave tubes and their applications.

The shaped winding pictured here produces the empirical function in the graph. It is an example of Fairchild's leadership in non-linear potentiometer design which started with their very first potentiometer over fifteen years ago—a functional unit designated Type 736.

VOLTAGE OUTPUT

ANGULAR SHAFT ROTATION

FAIRCHILD
PRECISION POTENTIOMETERS
and COMPONENTS

NON-LINEAR FUNCTIONS

featuring advanced techniques for winding precision potentiometers

The superiority of Fairchild functional components can be traced, in part, to the advanced winding techniques developed by Fairchild engineers. The shaped card shown above is one of these; others include wire size changes (butt welded instead of soldered), variable space winding, and the use of welded taps. After thorough inspection, the completed windings are curved and fitted into the potentiometer cases.

Over 2500 Functions

These advanced techniques, in many cases, avoid the need for tapping and shunting, and eliminate external resistors. Advances like these are the natural outgrowth of Fairchild's broad experience attained in manufacturing precision potentiometers to produce more than 2,500 different non-linear functions.

Some of the more common of these include:

$$R = KV\sqrt{}$$

$$R = \sin 2\theta$$

$$R = K \frac{\sin^2 \theta}{2}$$

$$R = 1 - \cos(90^\circ - \theta)$$

$$R = 1 - \cos \pm 90^\circ$$

$$\% R = \% \theta^2$$

$$\text{Sec. } \theta$$

$$\sin - \cos$$

$$1.875 \log$$

$$2 \text{ cycle log}$$

These functions can be provided in many standard types ranging from $\frac{1}{8}$ " to 3", as well as an infinite variety of specials. Call on this vast experience the next time you have a problem involving non-linear functions—or any precision potentiometer problem. Write to Dept. 140-89X, Fairchild Controls Corporation, Components Division:

EAST COAST
225 Park Avenue
Hicksville, L. I., N. Y.

WEST COAST
6111 E. Washington Blvd.
Los Angeles, Calif.

For more information circle 16 on inquiry card.

UHF Applications

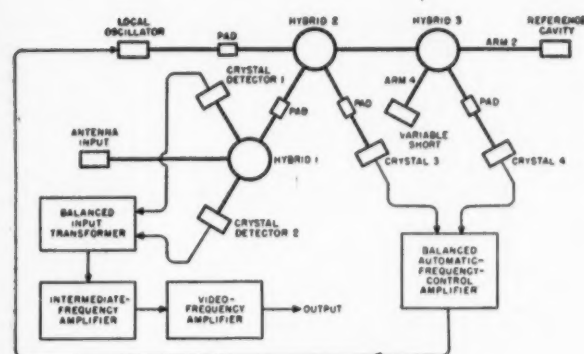


Fig. 5-1

PRINTED CIRCUITRY V

Printed-circuit techniques have an important place in UHF and microwave equipment, including transmission lines, filters, antennas and resonant circuits. Special design considerations include impedance matching, power limitations, conversion from balanced to unbalanced conditions, radiation effects, and dielectric losses.

ALLAN LYTEL, General Electric Company

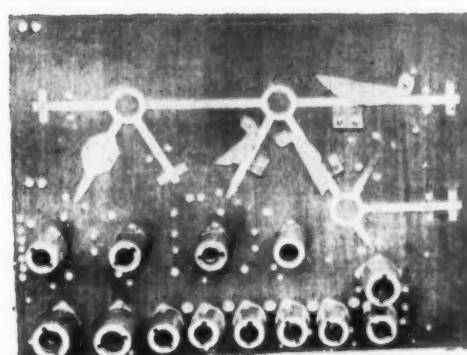


Fig. 5-2

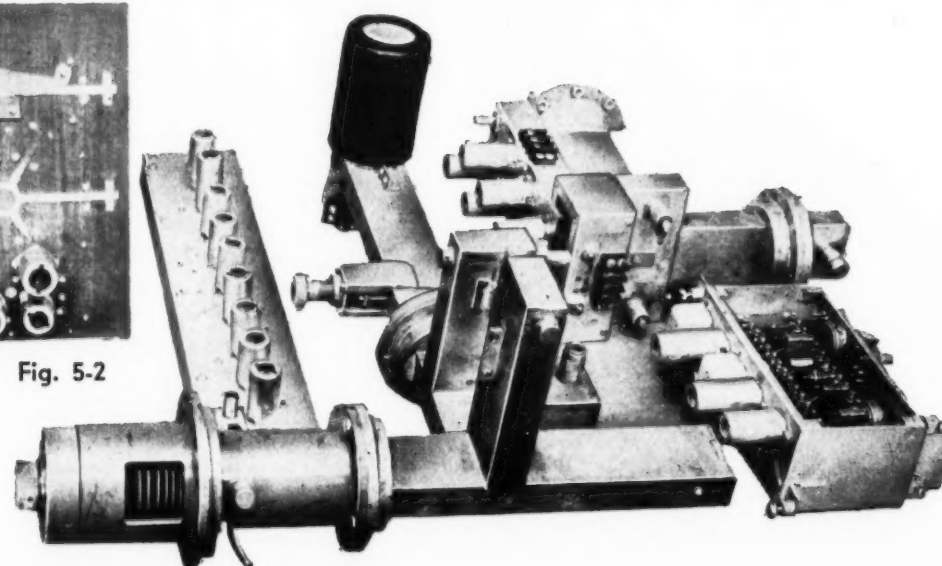


Fig. 5-1. Block diagram of the receiver showing the Microstrip parts in heavy lines. (Drawing courtesy Federal Telecommunications Labs., IT&T)

Fig. 5-2. Microwave receiver constructed with standard microwave "plumbing" weighs 32 lb; its "Microstrip" equivalent weighs 5 lb and also costs less to build. The photographs are to scale; the width of the Microstrip receiver is one foot. (Photo courtesy Federal Telecommunications Labs., IT&T)

Fig. 5-3. Field distribution in parallel plate line at A and Tri-Plate line at B. (Drawings courtesy Sanders Associates)

Fig. 5-4. Types of printed-circuit transmission lines. A shows "Microstrip;" B shows "Tri-Plate;" C, D and E show "Stripline."

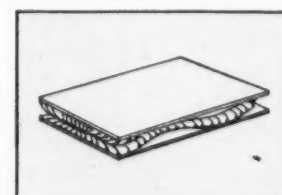
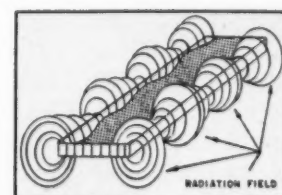
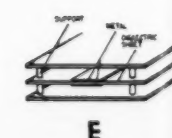
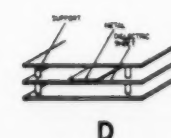
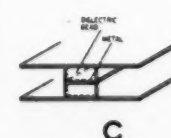
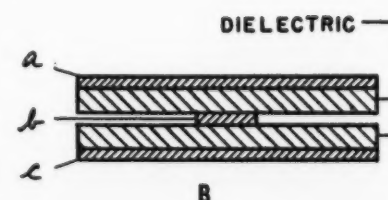
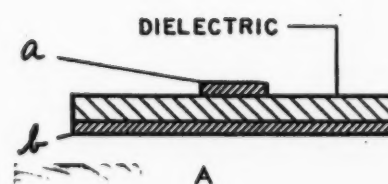


Fig. 5-3



PRINTED-CIRCUIT UHF and microwave equipment has advantages over conventional construction, including simplicity, easier fabrication, lower cost, and less space required. Fig. 5-2 compares a conventional microwave receiver to the equivalent Microstrip-wired* receiver. At frequencies between 4400 and 5000 mc, the Microstrip receiver has the characteristics shown in Table 5-1.

Fig. 5-1 shows a block diagram of this receiver: hybrid 1 receives the input r-f signal and the local oscillator signal. The i-f (60 mc) is applied to the i-f amplifier and through the rest of the receiver. At hybrid 2 the power from the local oscillator splits going to hybrid 3 and crystal 3. At hybrid 3 the signal is again split going to the reference cavity and the variable short. (Hybrids are Y junctions that can split or mix microwave signals.) The difference between the local oscillator signal, the signal generated by the reference cavity, and the variable short is used to control the local oscillator through the AFC amplifier.

In this case the use of printed-circuit techniques permitted a reduction of 6 to 1 in weight, the elimination of parts such as flanges, and a considerable reduction in cost. The unit construction of this receiver also permits more rapid repair and servicing.

Transmission Lines

Three printed-circuit transmission lines are shown in Fig. 5-4. Microstrip, part A, is a printed-wire two-wire transmission line. Conductor (a) is printed on one side of the Teflon-fiberglass base. (The characteristics of this base material are given in Table 5-2.) The other surface of the dielectric also has a printed wire (b) which acts as a conducting plane. Microstrip has a rather high dielectric loss and requires shielding to prevent radiation loss; it is successful where a high Q is not required, or for short runs of transmission line. A typical transmission line with the conductor strip about 0.0013" thick and 0.220" wide separated from the ground plane (also 0.0013" thick) by a 0.062"-thick Teflon-fiberglass board has a characteristic impedance of 50 ohms.

Tri-Plate** (Fig. 5-4, B) can be considered the printed equivalent to coaxial transmission line. A single conductor positioned between two ground planes produces a Tri-Plate transmission line. Tri-Plate eliminates the radiation leakage of Microstrip and is more rigid; its dielectric loss, however, is higher.

Stripline*** (Fig. 5-4, C, D, and E) is formed so that a flat conductor is centrally placed between two ground planes. The flat conductor can be either a solid copper strip or a dielectric sheet with a printed conductor. In C, the ground plane is bound to a dielectric sheet, and the flat center conductor is supported by dielectric beads. This structure has no significant dielectric loss or radiation leakage because of the air spacing. It is comparable

to equivalent-size coaxial line. If necessary, the center conductor strip can be undercut at bead supports to provide a constant characteristic impedance; as with any beaded line the beads cause a slight mis-match. In part D, a dielectric sheet between the two ground planes carries a single copper conductor and the dielectric sheet is supported by either metal or dielectric posts. Dielectric losses are present, but small, because the dielectric sheet is thin. Also a low-loss dielectric sheet is generally used, the most common being Teflon-glass. This material has a dielectric constant of 2.6 and dissipation factor of 0.0007 (at 1 mc).

However, most of the dielectric between the strip conductor and ground planes is air. The double metal clad line, part E, has even lower losses because (if the two strips are connected in parallel at the input and output of the circuit) the electric fields exist from each strip conductor to its corresponding ground plane and only fringing fields exist in the dielectric sheet. In a resonant structure, however, strong fields exist at the voltage maxima and the dielectric is removed from these regions. The losses of the bead line, as in C, and the double metal clad line, as in E, are then comparable and very low; the losses of the single metal-clad line (D) are somewhat greater but still low.

Studies were made with both the Stripline and the parallel-plate lines; the fields which were present are shown in Fig. 5-3. Notice that with the parallel plate line there is a large external field because of the difference of potential between the two conducting plates. Stripline fields are more confined because the distribution is from the inner conductor to each of the outer conductors as shown.

Stripline has a high Q which makes this line suitable for resonant applications. Typical unloaded Q and attenuation characteristics for silver-plated Stripline with 1/4" and 1/2" ground-plane spacings are shown in Fig. 5-5. These characteristics apply to both the bead line and the double metal clad line. The attenuation of silver-plated 77-ohm air coaxial line also is shown. The attenuation of Stripline compares favorably with that of equivalent size coaxial air line. Also shown is the computed attenuation for silver-plated standard-size waveguide for X-band.

Stripline limitations are: (1) The ground-plane spacing must be less than one-half wavelength, (2) the electrical width of the center conductor must be less than one-half wavelength, and (3) the center conductor must be centered between the ground planes and parallel to them.

Limitations on physical size limit the Q that can be obtained because certain undesired higher modes must be avoided in some applications. The unloaded Q of Stripline increases as either the ground-plane spacing or the width of the strip is increased. If even higher Q's are desired than normally obtained within the usual limitations of physical size, it is possible to increase the width of the strip beyond 1/2 wavelength. However, dimensions must be chosen so that transverse resonance of the higher undesired modes in the strip are avoided.

Table 5-1. Technical characteristics for microwave receiver.

Operating frequency	4400—5000 megacycles
Frequency stability	±0.02%
Selectivity	10 megacycles at 6 decibels down 20 megacycles at 60 decibels down
Sensitivity	Minimum signal = 4×10^{-12} watt (Signal power = $4 \times$ noise power)
Noise factor	13 Decibels maximum
Intermediate frequency Converter	60 megacycles Balanced mixer with 1N23B crystals
Local oscillator	Reflex Klystron
Automatic frequency control	Cavity controlled
Gain of automatic frequency-control amplifier	66 Decibels minimum
Gain of intermediate-frequency amplifier	100 Decibels minimum
Gain of video-frequency amplifier	30 Decibels minimum

Table 5-2. Characteristics of Teflon-fiberglass dielectric.

Dielectric constant at 1 megacycle	2.60
Dissipation factor at 1 megacycle*	0.0007
Loss factor at 1 megacycle*	0.002
Dielectric strength in volts per mil at 25 degrees Centigrade	500
Maximum operating temperature in degrees Centigrade	250

* As defined in American Society for Testing Materials Designation D-150-47T.

Table 5-3. Environmental test results of Stripline resonator at S-band.

Temperature	Humidity	Unloaded Q
-55°C	very low	2760
+25°C	35%	2420
+70°C	98%	1850

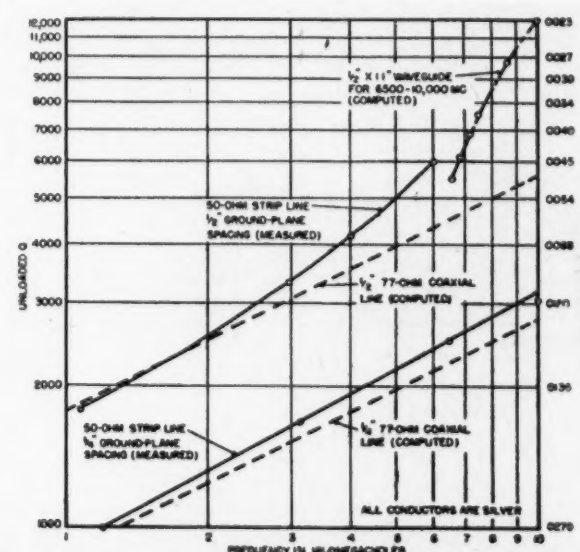


Fig. 5-5. Q and attenuation characteristics. (Drawing courtesy Airborne Instruments Lab.)

* Federal Telecommunications Laboratory (IT&T)

** Sanders Associates

*** Airborne Instruments Laboratory

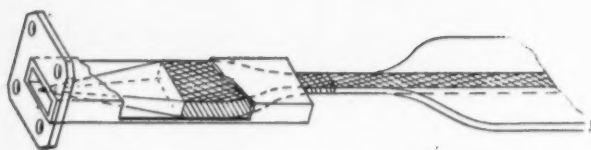


Fig. 5-6. Polystyrene transition from waveguide to parallel plate line.

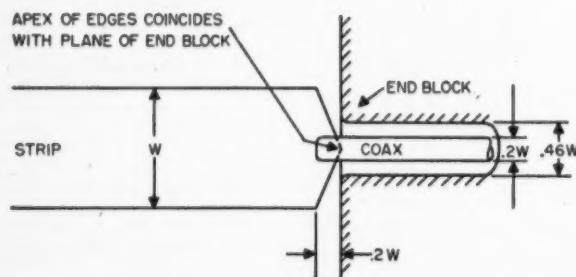


Fig. 5-7. Fifty-ohm coaxial-to-strip transition.

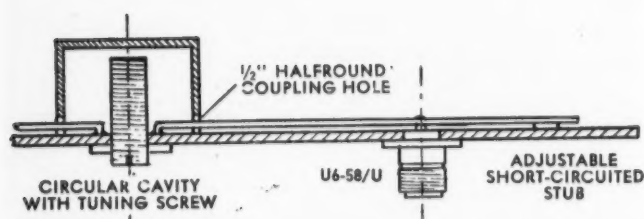


Fig. 5-8. Printed-line-to-coaxial coupling (right) and a resonant cavity (left).

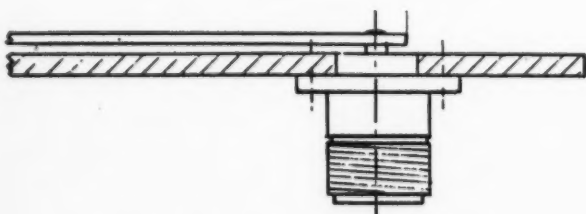


Fig. 5-9. Open-ended transmission-line stub.

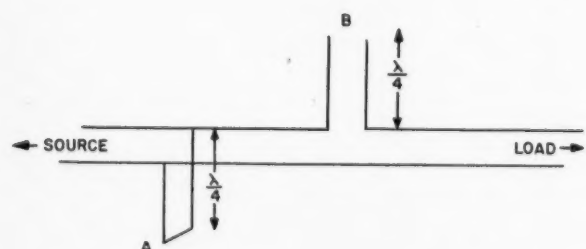


Fig. 5-10. Transmission-line stubs. A represents shunt inductance; B shows a series capacitance; both are resonant at frequency with wavelength λ .

The theoretical power limitation of Stripline of arbitrary dimensions has not been established. Tests at S-band have been made with $\frac{1}{4}$ " ground-plane spacing. The power handling capacity of 50-ohm bead-supported strip line has been found to be at least 100 kw peak. At L-band the power handling capacity with $\frac{3}{8}$ " ground-plane spacing is at least 150 kw peak.

Tests on Stripline (double metal clad with Teflon-glass dielectric) high-Q resonators at S-band indicate the humidity and temperature effect on Q is small (Table 5-3).

Transmission-Line Transitions

Many r-f systems use both printed and other types of transmission lines, requiring transitions between the different types of lines. In Fig. 5-6, a parallel-plate line is shown meeting a waveguide. The sandwich of metal and dielectric is made wider as it extends into the waveguide until it fills the guide. A wedge-shaped section of polystyrene allows gradual transfer of energy from the printed line to the guide so that reflections and energy loss are minimized.

Fig. 5-7 shows a transition between a strip and a coaxial line; dimensions are in terms of the width (W) of the strip. The triangular end of the strip connects directly to the center conductor of the coaxial line.

Coupling between a single strip, mounted above a ground plane, a cavity and a coaxial line is shown in Fig. 5-8. On the left side the line is taken into and out of a tuned cavity. The volume of the cavity is varied by changing the position of the threaded adjustment thus changing the resonant frequency. The transmission lines enter and leave without touching the sides of the cavity; each line is terminated in a shorted stub with impedance, Z_{in} , defined as:

$$Z_{in} = Z_0 \tan \theta$$

where Z_{in} = the impedance at the load end of the stub; Z_0 = the characteristic impedance of the line from which the stub is made; θ = the electrical length of the stub in degrees.

At the right of Fig. 5-8 the printed-wire line again terminates in a shorted stub, which is the length required to match the coaxial line impedance. Impedance matching provides for maximum transfer of energy from line to load.

In Fig. 5-9, a printed-wire line is matched to the coaxial connector by an open-ended line stub with impedance, again a function of line length, expressed as:

$$Z_{in} = -Z_0 \cot \theta$$

The formulas for the open-ended and shorted line stubs show it is possible not only to provide matching but also possible to produce capacitive and inductive reactances of various values for filters with these line stubs.

Filters

Printed transmission line sections can be used as filters just as ordinary transmission line sections. (Note,

impedance is a function of the section termination, length, and operating frequency.) If the stubs are less than one quarter wave-length, an open-ended stub will be capacitive and a shorted stub will be inductive. In Fig. 5-10, A represents a shunt inductor; B represents a series capacitor. In B, as length is decreased from about 90° (this is measured in electrical degrees of travel, which is the velocity in free space adjusted by dielectric effects), the capacitive reactance increases. At 45° the capacitive reactance is equal to the characteristic impedance of the line and this reactance becomes very large for a line stub less than 10° long.

A shorted line is quite different; at a 90° length, it is a parallel resonant circuit. As the line length is decreased toward zero, the inductive reactance decreases until the value for a 10° line is close to zero. All of the filters required for an r-f system can be made using the proper combination of these stubs as capacitors and inductors.*

Several interesting techniques are used in construction of these filters. Stripline elements grounded at the outside edge act as inductances. Series capacitors are formed by breaking the top and bottom strips in the main line at slightly different points. These strips overlap each other and form a small capacitor with base-material dielectric.

JHF Resonant Circuits

Modifications of printed transmission lines can result in resonant circuits. The cylinder in Fig. 5-11 has a core in the center made of ferrite supported by the dielectric material that fills the cylinder. The cylinder diameter permits only the desired mode of operation.

Two Tri-Plate lines are used for input and output. Their two outer plates are tied directly to the outer cylinder of the resonator. The inner plates of the lines are wound around the core through the dielectric material inside the metal cylinder.

With an external magnetic field, this cylinder can operate as a gyrator to introduce a required phase-shift. A cylinder such as this, without the core, will act as a resonator if it is cut to the proper length and capped on both ends.

Stripline Converter

A Stripline converter designed to operate at 1600 mc with a 60-mc intermediate frequency is compared to a conventional tuner in Fig. 5-12. The cavity, which is the main body of the converter, is shown in Fig. 5-13; this is the equivalent of the resonant cavity used with waveguides.

Spacing between the ground planes is kept below a half wavelength so that no spurious modes will be introduced. If the ground-plane spacing is much less than $\frac{1}{2}$ wavelength, the attenuation of the field transverse to the

*UHF Practices and Principles, by A. Lytel, John F. Rider, published New York, N. Y., 1952, p 145-149.

strip will be very high; and ground-plane width dimensions can be made smaller without introducing radiation from the cavity.

The brass blocks used to support the copper strip between the two ground planes act as short-circuiting elements between the strip and ground planes. The contacting surfaces of the blocks should be flat and smooth to ensure a good contact.

The copper strip (Fig. 5-14) is $\frac{1}{16}$ " thick and its length outside the short-circuit blocks is about $\frac{1}{4}$ wavelength. It can be represented by the wavelength equation:

$$L = \frac{\lambda}{4} = \frac{V}{4f_0}$$

where λ = wavelength; V = velocity of light in free space; f_0 = cut-off frequency in cavity.

Theoretically the ground planes should have an infinite width with respect to the strip, to eliminate radiation. In practice, the minimum width of the ground plane is about two and one-half times the width of the conductor strip; and the length of the ground planes is approximately a half inch longer than the strip at the open end. The strip and the ground planes are bolted together at the short-circuit end as firmly as possible to prevent stray losses.

Fig. 5-15 shows the crystal mount located opposite the signal input loop; the crystal forms a loop with the short-circuit blocks. A thin Teflon tape is placed between the mount and the short-circuit blocks to form an r-f bypass.

Electrically, the Stripline converter is comparable to the coaxial converter; the present conversion loss can be further improved by plating all parts with silver.

Antennas

Antennas are, in effect, special resonant sections of transmission lines.

Baluns (Balance-to-Unbalance Converters)

Conversion from an unbalanced to a balanced line is required by some antenna applications. Several of these converters or baluns are diagrammed in Fig. 5-16. In A, the two points of take-off for the balanced pair are 180° or $\frac{1}{2}$ wavelength apart. Thus the two feed points are out of phase and are joined to form a balanced line. In B, the two feed points for the balanced line are electrically identical but an extra $\frac{1}{2}$ wavelength of electrical travel is introduced in one leg so that there is 180° difference between the two lines. In C, a balun is introduced as a transition between a coaxial line and the balanced printed-wire line; again an extra 180° of travel is introduced in one leg.

Striplines fundamentally are unbalanced transmission lines; but several types of balanced lines are possible. One method uses two strips face-to-face on either side of a dielectric strip. This would have a strong field inside the dielectric which is not desirable. A second type also uses two strips; but they are offset and not facing each other. The third type uses four strips, two on one side

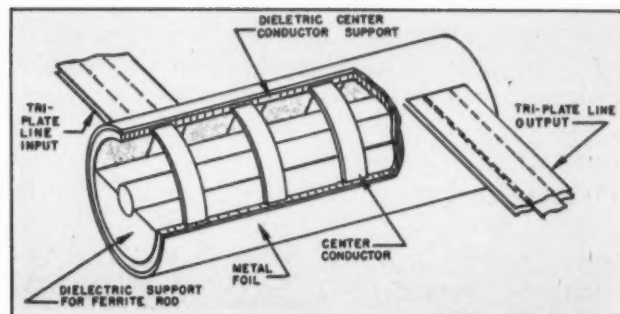


Fig. 5-11. Typical Tri-Plate gyrator. (Drawing courtesy Sanders Associates)

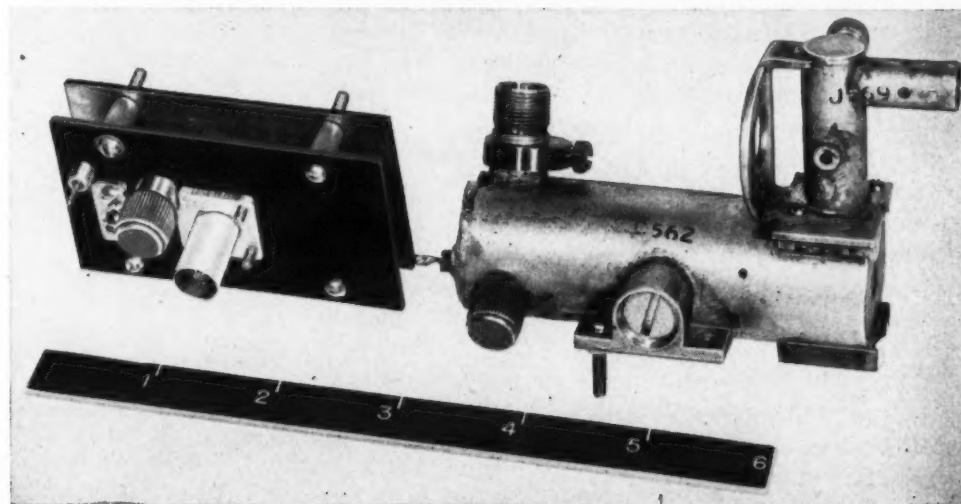


Fig. 5-12. UHF converters; printed-circuit equivalent is at left. (Photo courtesy RCA)

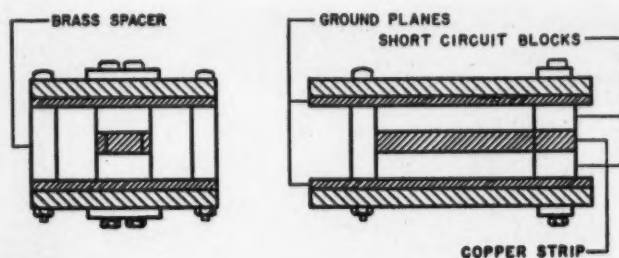


Fig. 5-13. Section of Stripline cavity used in UHF converter.

Fig. 5-14. Printed strip.

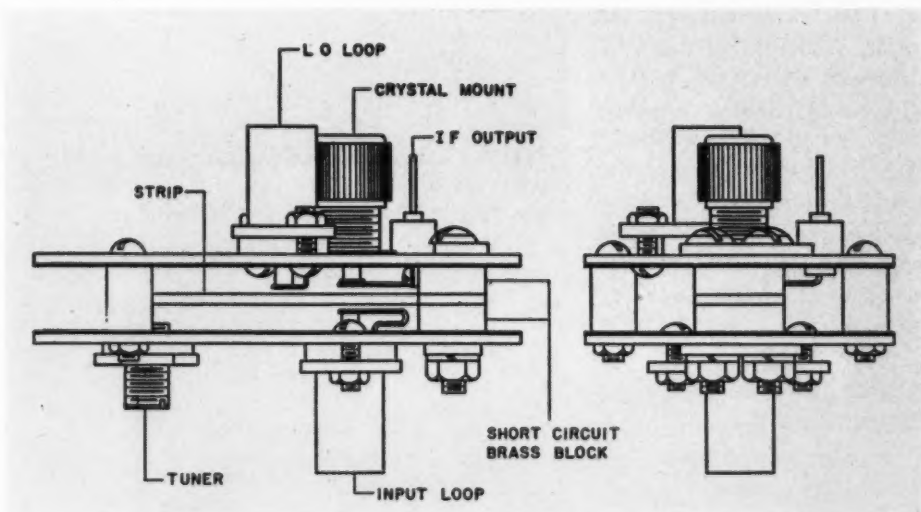
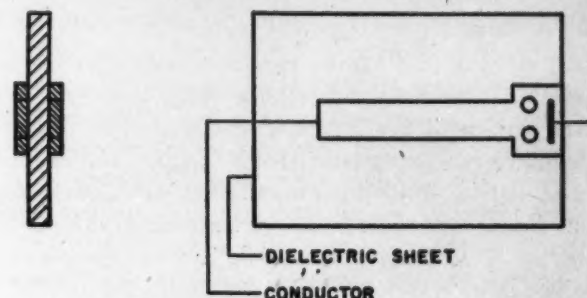


Fig. 5-15. Section of Stripline converter.

and two on the other side of the strip. The two facing strips are at the same potential. This line is equivalent to a conventional two-conductor line with part of the space between the two conductors filled with dielectric. The latter two types reduce the field inside the dielectric and therefore reduce the losses and bring the velocity of transmission closer to that of radio waves in air.

Antenna Arrays

The use of transmission line "twists" is shown in Fig. 5-17. In this broadside array the three dipoles should be separated by a physical $\frac{1}{2}$ wavelength. But if this is done as in A, the successive dipoles will be electrically 180° apart (assuming that $\frac{1}{2}$ wavelength on the line is the same distance as $\frac{1}{2}$ wavelength in air). The solution, shown in part B, is to twist the transmission line. Now all dipoles are in phase while still maintaining the same physical separation of $\frac{1}{2}$ wavelength.

It is also possible to effect "twists" in the type of Stripline balanced line shown in Fig. 5-18 by printing the radiating elements on one or the other side of the dielectric sheet connecting to the proper conductor for that point in the array. Because the thickness of the sheet is only a small part of a wavelength, the antenna characteristics are not changed.

In Fig. 5-19, half-wave antennas are fed in series in a collinear array. Antenna sections are separated by $\frac{1}{2}$ -wave sections of transmission line to provide the required 180° of travel.

Complex antennas can be reproduced with high accuracy with printed techniques. Fig. 5-20, shows a continuous-wire array with center-fed zig-zag conductors.

Slot Antenna

An antenna that can be mounted flush with a vehicle surface can be made by etching the proper hole in the outer surface of the Tri-Plate line (Fig. 5-21). Because this hole, bounded on each edge by copper, acts as dipole, the excitation from the transmission line causes radiation. However, to match the feed system to the antenna, a series of shorting pins usually are mounted between the two outer conductors. The slot across the face of the Tri-Plate line is a series slot antenna with a single slot shown in Fig. 5-21. Where L is the wavelength, the slot is $\frac{3}{5}L$ long and $\frac{1}{20}L$ wide. Antennas of this type have wide applications in high-speed aircraft where their flush mounting reduces drag; also installation is easy.*

* * * * *

The chapters that follow include:

Circuitry, including Packages (in next issue)
Production, including Automation
Servicing

*Sinclair, G., *Proc. IRE*, Vol 36, December, 1948, p 1487.

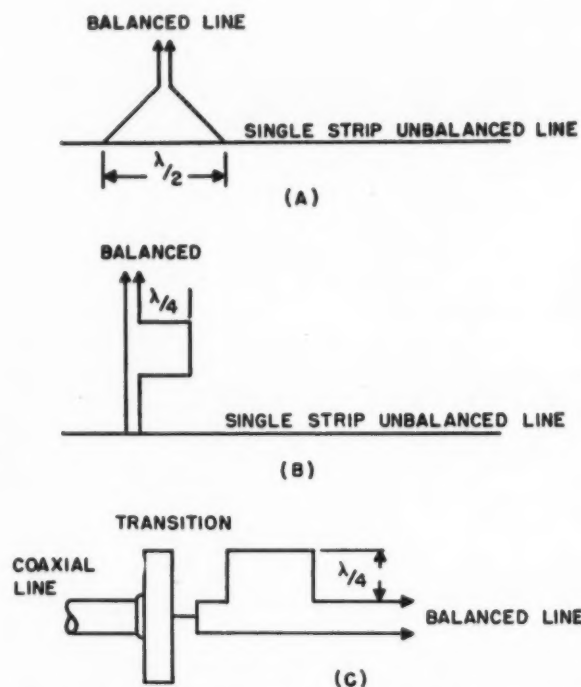


Fig. 5-16. Transitions to balanced lines with baluns. (Drawing courtesy Airborne Instruments Lab.)

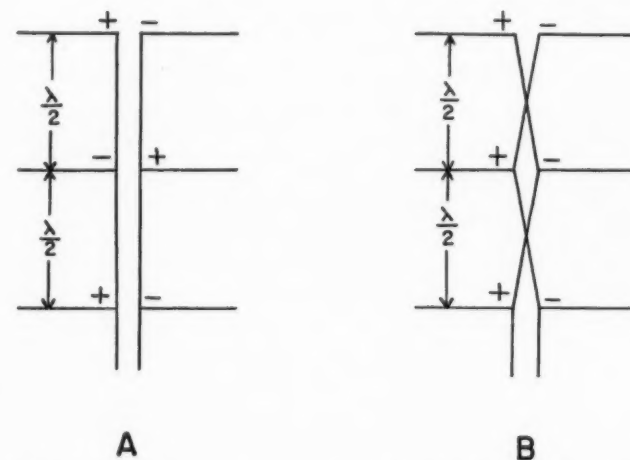


Fig. 5-17. Antenna transmission line feeders show cross-overs at B necessary for proper dipole array. (Drawing courtesy Airborne Instruments Lab.)

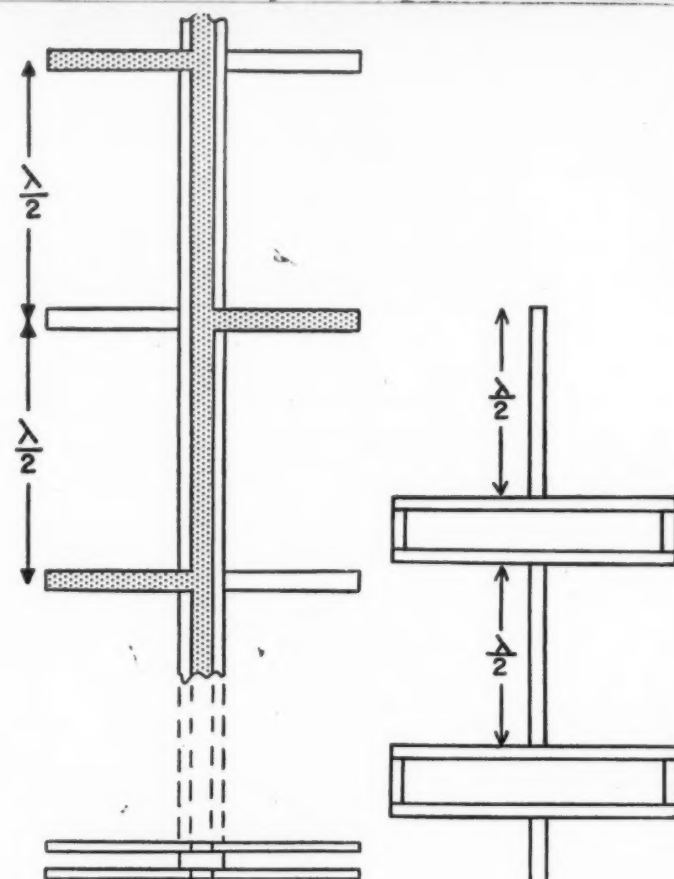


Fig. 5-18. Antenna "twists" effected by connecting alternate radiating arms to top and bottom conductors.

Fig. 5-19. Phasing sections between radiators for proper in-line phasing. (Drawing courtesy Airborne Instruments Lab.)

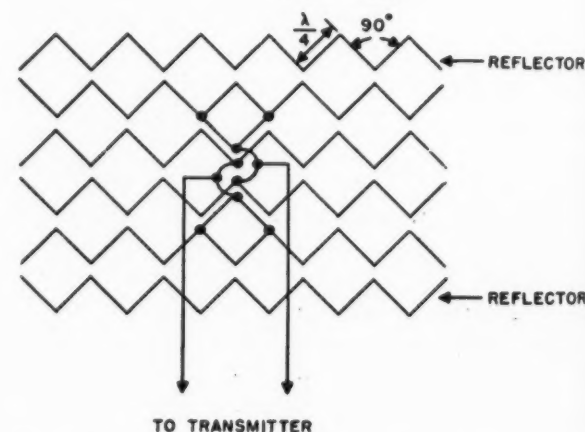


Fig. 5-20. Zig-zag antenna array. (Drawing courtesy Airborne Instruments Lab.)

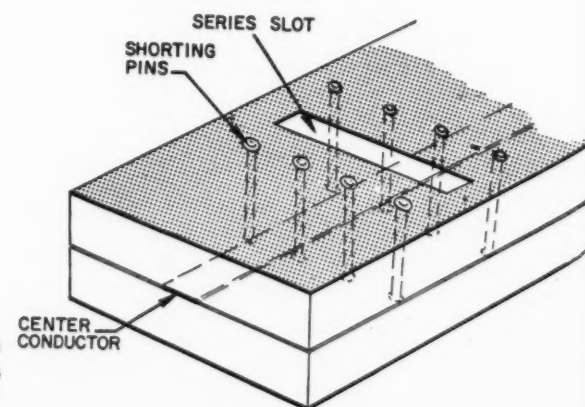
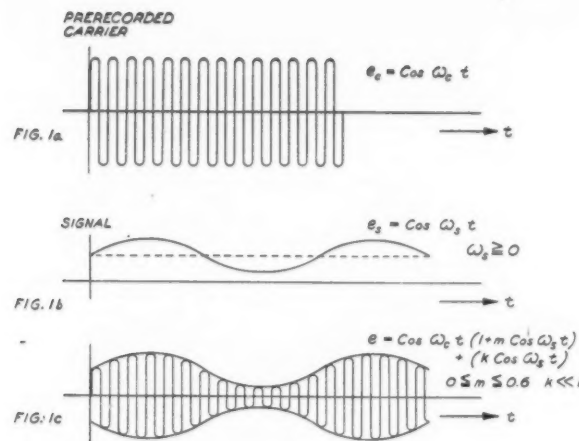


Fig. 5-21. Series slot in Tri-Plate transmission line can be a flush-mounted antenna. (Drawing courtesy Sanders Associates)

Three Types of Recording with 4½-lb Recorders

CARRIER ERASE recording (Fig. 1) uses a sinusoidal carrier that is first pre-recorded on the tape prior to data acquisition. Then instrument signals ranging in frequency from dc to approximately 1/4 of the pre-recorded carrier frequency partially erase the pre-recorded carrier. On playback, the amplitude of the residual (unerased) signal will be an essentially linear function of the amplitude of the phenomena measured. The outputs of such instruments as thermocouples, thermistor bridges, strain gages and other d-c or low-frequency a-c devices can be accurately recorded with this technique.

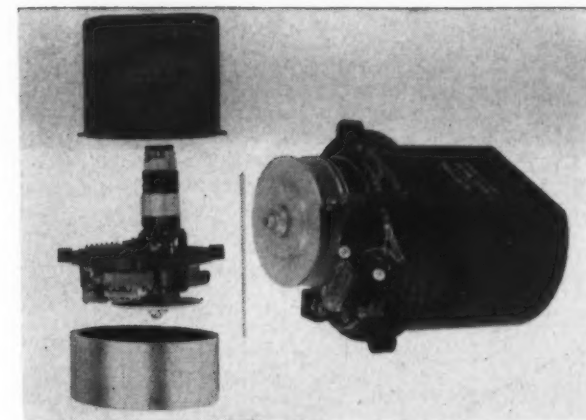
FM carrier recording has numerous channels of information multiplexed on a single track; greater accuracy can be achieved and, using the RDB subcarrier



Carrier-Erase Recording Mode—instrument signals partially erase pre-recorded carrier.

frequencies, bandwidth extends from dc through about 1/50 of the carrier frequency. A typical recorder can be used to record 35 channels of data and reference information by recording five RDB channels per track. A transistorized bias oscillator is used to linearize recorder tape response and to keep the FM carriers from mixing non-linearly.

Direct AM recording permits storage of large quantities of a-c information in shorter lengths of tape and at lower tape speeds than are required for a carrier system. Linear AM recording requires use of a bias



Airborne MR-50 Recorders use Carrier-erase, FM carrier and direct AM recording modes.

oscillator as with FM carrier recording.

Dimensions of four new MR-50 series recorders that provide any of these recording modes are 5.3" dia and 7" long (Fig. 2). Weight is 4.5 lb without armor. These recorders are designed to record through at least 250 g's shock axially and 50 g's transversely, and to survive 1200 g's without major damage. Recorders are available from Northam Electronics, Inc., 2420 North Lake Ave., Altadena, Calif.

For more information on Northam Recorder circle 201 on inquiry card.

Laboratory Test Fits Fans to Job

EFFECTIVENESS of cooling fans or blowers for electronic equipment is often improved with a venturi ring designed to match the static pressure conditions of the system to be cooled. Particularly in air-

craft applications where the same cooling is necessary at high altitude as at sea level, and where weight and efficiency are important, an axial fan can give superior performance if such a ring is constructed to match

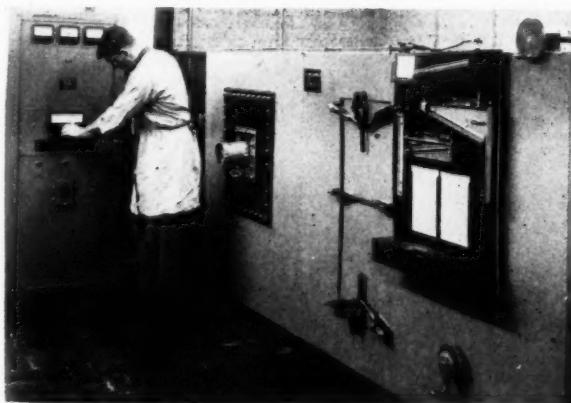


Fig. 1. Specialized Test equipment ensures that fan-ring-motor combination meets job requirements.

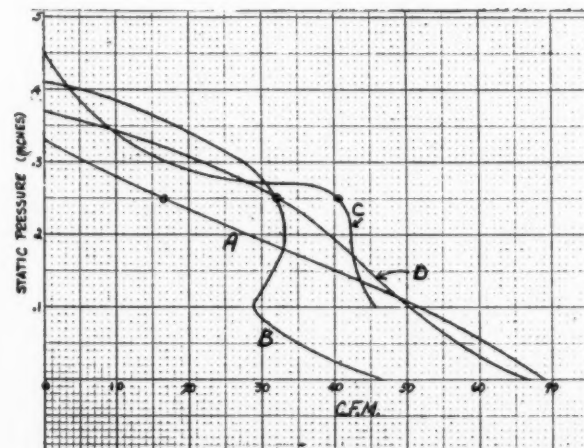


Fig. 2. Problem: To deliver 30 cfm at 0.25" static pressure without turbulence. Curve D shows best combination and efficiency.

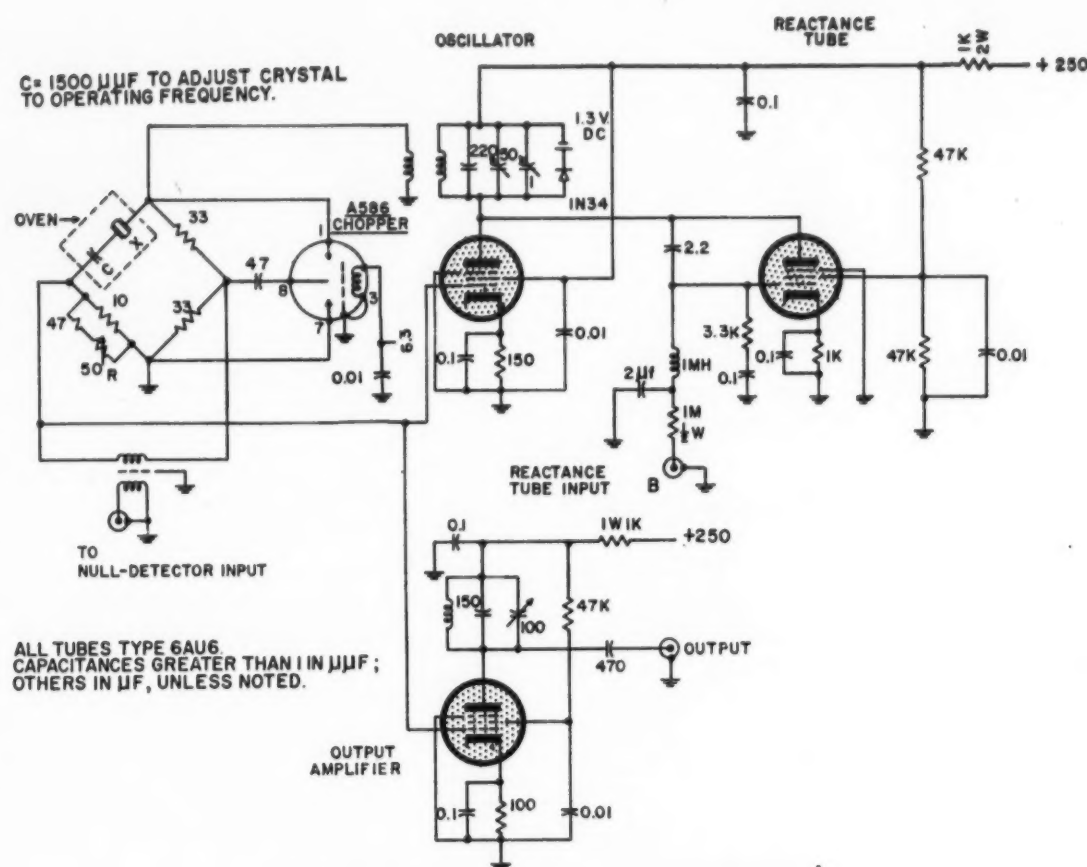
the application.

A specialized facility constructed in accordance with NEMA standards provides for accurate testing of different fan, motor, and venturi combinations under a wide range of cfm and static pressure conditions. In a typical study of a blower in the plenum chamber, a curve plotting air flow against static pressure was run with a standard venturi-ring design. The initial trial (curve A) showed that the fan-ring combination would give good results at a low static pressure. However, operating conditions for this particular application called for 0.25" of static pressure. To move the required 30 cfm at that pressure this fan ring would require more power.

Trials B and C reflect changes that developed the necessary volume and pressure but exhibited turbulent conditions in the region of the operating point, which indicated probable erratic results in the field and also that manufacturing tolerances would be critical. Ring design D, however, gave the specified flow of 30 cfm at 0.25" static pressure without showing a turbulent condition at any point in the curve.

The testing procedures also check life, humidity, cold start, and air delivery characteristics of the fractional horsepower motors and associated blowers manufactured for industrial and military applications by Air-Marine Motors, Inc.

For more information on AMM Fans circle 202 on inquiry card.



Circuitry for Military Applications

A continuing MILITARY AUTOMATION feature, these circuits are selected because they represent good design in military applications. Significant characteristics which are not self-evident from the diagram are explained in the printed commentary. The circuits in this issue are from the book, *One Hundred Electronic Circuits*, by Milton H. Aronson and Charles F. Kezer, Instruments Publishing Co.

PORTABLE SECONDARY 1-MC FREQUENCY STANDARD

Frequency of this oscillator, developed at the National Bureau of Standards, is constant to a few parts in 10 billion per day. Frequency is almost independent of tube, supply, and component changes. This unusual stability is obtained by close temperature control and a novel circuit in which the 1-mc AT-cut crystal does double duty as the oscillator tank circuit and as the frequency-determining element of a low-impedance resonance bridge.

Frequency of the oscillator is controllable over a small range by a reactance tube. Reactance tube is controlled by a null detector-amplifier (shown in next circuit) to match oscillator frequency to the crystal. In this way, oscillator stability is made to approach that of the crystal, which would otherwise be impossible because of random phase-shift changes in the oscillator circuitry.

The crystal bridge is normally balanced to have minimum (near zero) output at the series-resonant frequency of the crystal. If the oscillator frequency is

off the correct value, output of the bridge will increase. This increased voltage is amplified and detected in the null detector-amplifier; it is also necessary, however, to detect whether the frequency is high or low. This is done with the chopper, which alternately shifts the bridge balance frequency upward and downward at a 60-cps rate by connecting the 47- μ mf capacitor across the resistive arms of the bridge. This switching has negligible effect on oscillator frequency, as oscillator output is at low impedance. When oscillator frequency is correct, bridge output is the same for either position of chopper contact. Difference in outputs is detected in the auxiliary null detector-amplifier (next circuit) which uses a synchronously driven chopper, and which controls the reactance tube shown in this circuit. Buffer amplifier shown at the bottom provides output.

Tubes: All 6AU6

Crystal: 1-mc AT-cut; resistance = 10 ohms; $Q = 10^6$.

B supply: 250 v (VR-tube regulated) at 105 ma.
Same supply is used for the following circuit.

Source: Peter G. Sulzer, NBS, Washington 25, D. C., as described in TR 1924, June, 1955.

1-MC NULL AMPLIFIER AND DETECTOR

This amplifier-detector circuit was developed for use with the 1-mc oscillator shown previously. It uses four 6AU6 pentodes. Three tuned-amplifier stages provide a voltage gain of 10^7 ; a crystal filter between first and second stages provides additional selectivity. The fourth 6AU6 tube is diode connected; it is switched by a chopper to charge alternately the two 0.1 μ f capacitors connected to its contacts. If the frequency of the 1-mc oscillator in the preceding circuit is correct, these capacitors will be charged equally, and the voltage output to the reactance tube at point B will be zero. If oscillator frequency is off, a 60-cps modulation of the 1-mc carrier will be present, and one of the two capacitors will be charged to a higher potential than the other, and an error voltage will be developed at point B. Polarity of this voltage depends on whether oscillator frequency is high or low because the chopper is driven in synchronism with the chopper in the preceding oscillator circuit.

Charging of the detector capacitors is as follows: When the chopper contact is in the left position, the diode cathode is grounded, and the 470- μ f coupling capacitor charges to the negative peak of the 1-mc voltage. After a number of cycles (circuit need not respond rapidly) this negative potential charges the left 0.1- μ f capacitor to an equal level. When the chopper arm is in the right-hand position, the right-hand 0.1-

μ f capacitor is charged through the diode on positive peaks of the 1-mc carrier. Ultimately it reaches the peak value of the 1-mc voltage. No charging of the left-hand 0.1- μ f capacitor takes place during this time because it is at r-f ground potential.

As the two 0.1- μ f capacitors are in series with respect to output B, their voltage difference appears at this point. Filtered output is provided by the 1-meg-ohm resistor and 0.1- μ f capacitor combination to remove any remaining r-f components.

B supply: 250 v, VR-tube regulated.

Source: Peter G. Sulzer, NBS, Washington 25, D. C., also TR 1924, June, 1955.

COMPENSATED VIDEO DETECTOR HAS 0.07 MICROSECOND FALL TIME

This video detector (NBS-BuAer Preferred Circuit PC20) is used to demodulate pulsed intermediate-frequency signals, as in radar receivers. (Output of detector will normally be fed to a video limiter.)

The diode is one-half of a 5726, a premium version of type 6AL5W. It is connected for negative pulse output, as required by the following limiter. Linear operating range extends from about 0.2 to over 4 v; nominal operation level is 0.6 v.

Input capacity is about 14 μ f, consisting of 4 μ f for the 5726 and wiring, plus the 10 μ f capacity of C_1 . Shunt capacity of following stage is also 14 μ f (10- μ f wiring plus 4 μ f for input capacity of following 5654 stage). Hence fall time without compensation is $2.2 RC = 2.2(2.2 K) 28\mu f = 0.136 \mu$ sec.

Components L_1 - R_1 - L_2 are added to reduce the fall time of the output pulse. Without compensation, fall time is 0.136 μ sec. Compensation reduces fall time by a factor of 2.06—to 0.066 μ sec—with 3% overshoot. Inductor L_1 (70 μ h) is wound to be self-resonant at the i-f frequency.

Input: I-f pulses, 20-70 mc.

Output: Rectified negative pulses, 0.6 v nominal level.

Input capacity: 14 μ f.

Fall Time: 0.066 μ sec, with 3% overshoot.

Source: NavAer 16-1-519, *Handbook of Preferred Circuits*, Navy Aeronautical Electronic Equipment, National Bureau of Standards, Washington, D. C.

300-V REGULATOR HAS 1% REGULATION

Output voltage of this regulator is constant within 1% under normal line and load variations encountered in military equipment. Output is 300 v at 200 ma (maximum). It is NBS Preferred Circuit 3A.

Circuit is a conventional series-regulator, with loop gain of over 1000. The 6080 (6AS7 equivalent) is chosen for its low plate resistance and high heater-to-

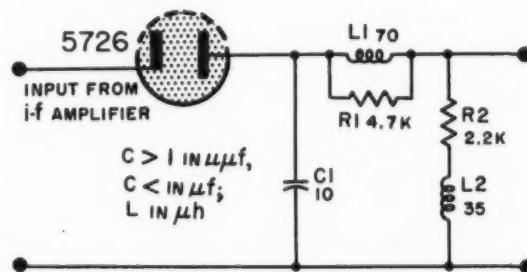
cathode voltage rating. The 33-ohm cathode resistors equalize the currents in the triode sections; the 470-ohm grid resistors suppress parasitic oscillations.

The network R_{12} - C_2 attenuates transient noise spikes characteristic of glow discharge tubes; R_{10} suppresses parasitic oscillation.

The 5751 (12AX7 equivalent) is a 2-stage direct-coupled amplifier that controls the series resistance of the 6080. The plate supply for the output section is taken from a voltage divider across the series tube in order to decrease the required plate swing. This is done as a compromise between (1) the high input voltage and (2) the steady output voltage. If the 5751 were fed from the input supply alone, an excessive plate swing would be required because as input increases, the output plate of the 5751 must swing negative to compensate. Hence using the input alone for the plate supply would require twice as much compensating swing.

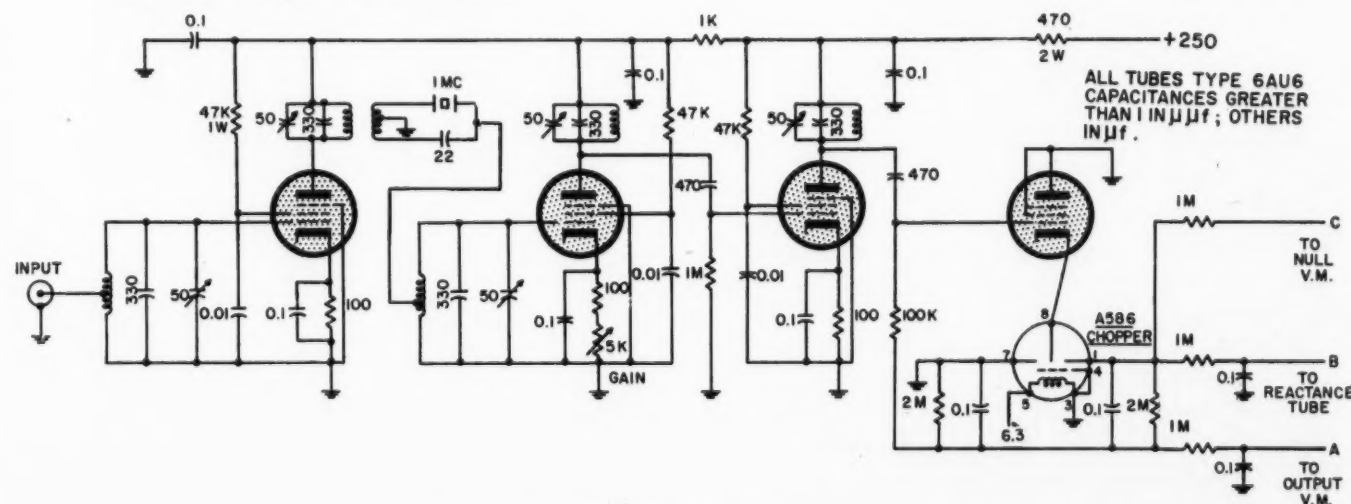
Feedback network R_5 - C_1 reduces the high-frequency output impedance.

Output capacitor C_5 should be at least 4 μ f; increasing it to 8 μ f lowers the output impedance at frequencies above 10 kc.



Compensated Video Detector

1-MC Null Amplifier and Detector



Resistor R_{17} decreases the output resistance and increases the stabilization by feeding a portion of the input voltage change to the cathode of the 5751.

The divider R_{18} - R_{19} - R_{20} across the output determines the fraction of the output voltage to be compared against the reference voltage, and hence this circuit is very sensitive to this divider ratio. Divider should use resistors whose wattage ratings are conservative and in the same ratio as the power dissipation in order to keep the ratio reasonably constant with temperature change.

Input: 350 v minimum.

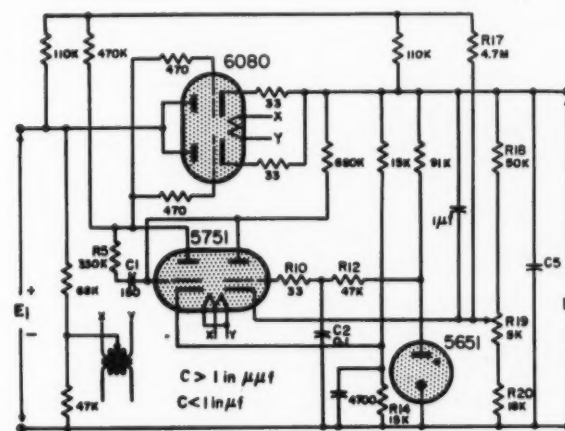
Output: 300 v.

Maximum load current: 125 ma per triode section of 6080 when one 6080 is used; 100 ma per section when 2 or more are used in parallel.

Regulation: ± 0.075 -v change in output voltage for $\pm 10\%$ change in input voltage; 100-ma change in load current produces 0.1-v change in output voltage.

Output impedance: 1 ohm or less from dc to 100 kc.

Source: NavAer 16-1-519, *Handbook of Preferred Circuits*, Navy Aeronautical Electronic Equipment, National Bureau of Standards, Washington, D. C.



300-V Series Regulator

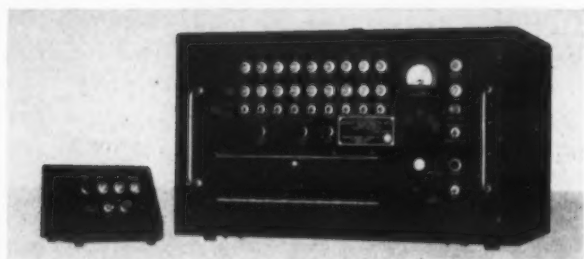


FIG. 1. AUTOMATIC FAILURE PREDICTOR monitors main functions of radar receivers, makes periodic checks on radar's components and sounds an alert warning of impending failure, thereby increasing reliability as much as 240%.

Failure Predictor Improves Radar Reliability

RELIABILITY of a radar receiver can be improved as much as 240% through prediction of impending failures. The *automatic failure predictor* (Fig. 1) monitors functions within a radar receiver and predicts impending failure; thus a unit can be replaced before failure.

The various functions of the radar receiver which can be continuously monitored are: Receiver crystal detectors, automatic-frequency-control (AFC) crystal detector and complete AFC unit, power supplies, transmit-receive (TR) tube, and overheat of the cabinet. An automatic programmer controls the sequence and type of monitoring. The sequence of operations also can be manually started from a remote station. A visible and audible warning of impending failure is given at the remote unit during automatic or manual operation.

The four modes of operation are:

1. Continuous monitoring for TR and overheat.
2. Continuous monitoring with automatic marginal checking for power supplies.
3. Automatic programmed monitoring for crystal detectors.
4. Automatic programmed monitoring with marginal checking for the AFC.

Adaptation of the automatic failure predictor to an existing radar is a matter of minor modification, with no effect on receiver operation. Reliability of the equipment is enhanced by transistor circuitry.

Unit has been developed by the Electronics Division of American Machine & Foundry Company's Defense Products Group, Boston, Mass., under a contract with Rome Air Development Center.

For more information on AMF Co. Failure Predictor circle 204 on inquiry card.

INFRARED RECONNAISSANCE

EFFECTIVENESS of infrared reconnaissance as a military weapon is strikingly revealed in a series of photos recently declassified by the U. S. Air Force.

These thermal mappings of military ground installations, airfields, and civilian sites show the ability of infrared techniques to translate into a photo pattern the warmth radiated day and night from the ground target (Fig. 1).

In a photograph of Idlewild Airport (Fig. 2) the runways stand out as "hot spots". These are areas which have absorbed the greatest heat from plane engine exhausts, friction of moving planes, auxiliary trucks and bright runway lights. As a result they generate more infrared radiation and, in the accompanying photograph, the runways appear as the bright areas. The darker areas are radiating less heat.

The sensitivity of the infrared technique is revealed

For more information on Infrared Systems circle 205 on inquiry card.

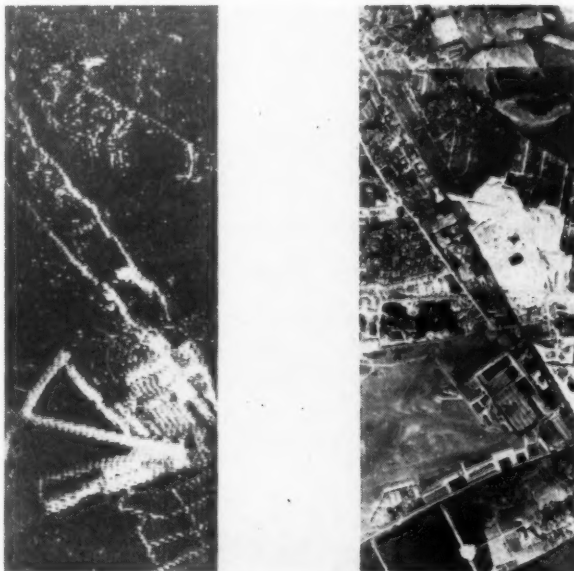


FIG. 1. THIS INFRARED PHOTO of Republic Aviation Corporation, Farmingdale, N. Y., (left) and the conventional aerial photograph were taken from an identical position. In the infrared photo, the runways (with engine exhaust, moving planes, auxiliary trucks, etc.—areas of greatest heat activity) show up clearly as bright spots. The plant (another "active" area) stands out as brilliant clusters of heat radiations. Another bright cluster is created by the factory building where furnaces, boilers and machine tools emit heat.

in the photograph of "Project Applejack" (Fig. 3). Here a plane flying at night at an altitude of 3000 feet, spotted military maneuvers in a heavily wooded area. In spite of total darkness, the photograph taken with the infrared system showed a road, a tank, its track, forest and a meandering river.

In all of these pictures, the bright areas indicate the areas of greatest activity, while the darker spots reveal a lesser degree of heat. From a military standpoint, this means that heavy industrial areas and specific targets such as factories, railroad yards, airports, etc. can be readily spotted by infrared reconnaissance.

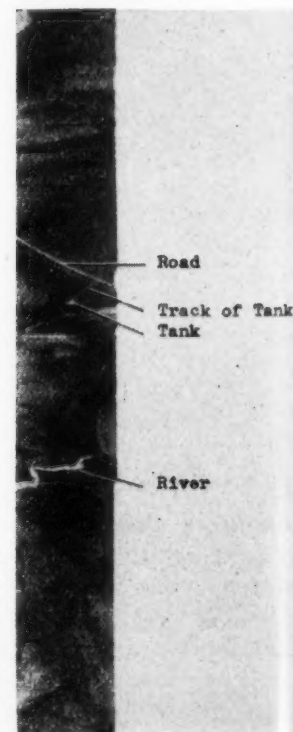
Another important characteristic of infrared reconnaissance systems is their ability to remain effective day and night and not reveal their position.

All photos were taken with an early system designed and manufactured by Servo Corporation of America, New Hyde Park, N. Y.

FIG. 2. INFRARED VIEW of Idlewild Airport highlights the runways where engine exhausts, auxiliary trucks and plane takeoffs and landings created ground heat. Taken at night, photo also shows hangar area and the pattern of busy highways.



FIG. 3. THERMAL RECORDING of "Project Applejack", taken in total darkness, shows a road, a tank, its track, forests and meandering river.



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FIG. 1. NEW JET-ENGINE FUEL-CONTROL test stand automatically charts performance characteristics of complex hydro-mechanical fuel controls used on jet engines. (Courtesy George L. Nankervis Co., Detroit, Mich.)



operations), (4) draw a graph after the test was completed from the readings obtained, and (5) when any portion of the test curve was out of limits, go back and make the necessary adjustments. This was time consuming because most jet-engine fuel controls have from 5 to 7 inter-related adjustments.

On the new test stand the two functions of operation and recording are done simultaneously. The acceleration and deceleration rate of the test is preset and the test is started by simply pressing a button.

The performance curve is drawn as the test progresses and, should it show a need for adjustment, the test can be stopped and the adjustment made immediately. It is not necessary to wait until the test is completed and the curves of the test runs made as in static test-stand operation.

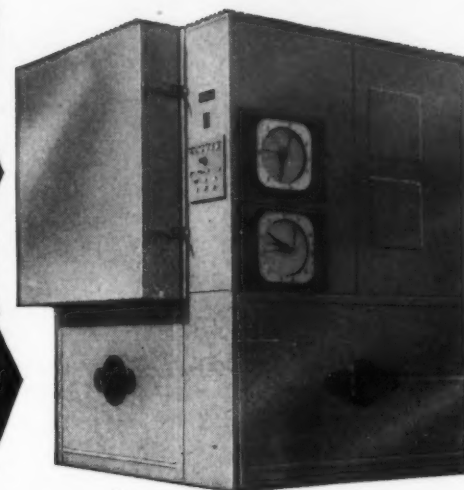
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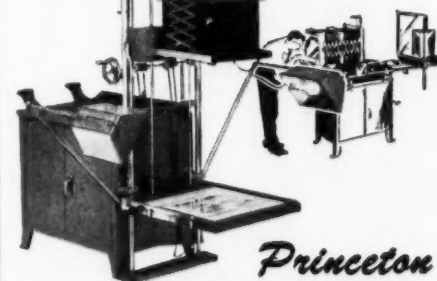
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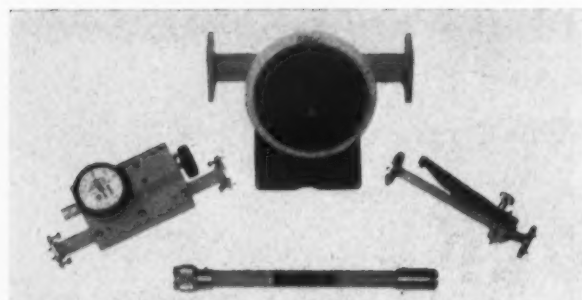


FIG. 1. METALLIZED GLASS MICROWAVE attenuators. These devices are of the dissipative type in which power is absorbed through ohmic loss by very thin metallic films coated on glass. In the coaxial-line types, a metallized glass tube forms the center conductor of a section of coaxial transmission line. In the waveguide types, the metallic films are coated on thin glass plates which are supported lengthwise within the waveguide with the film parallel to the electric field.

Microwave attenuators are used in isolation sections, signal generators and calibration standards, and to increase the range of power-sensitive instruments. This article on microwave attenuators begins a new series on microwave theory and techniques.

Microwave Attenuators

By Research and Development Group, Dr. M. J. DiToro, Director

POLYTECHNIC RESEARCH & DEVELOPMENT CO., INC. BROOKLYN, NEW YORK

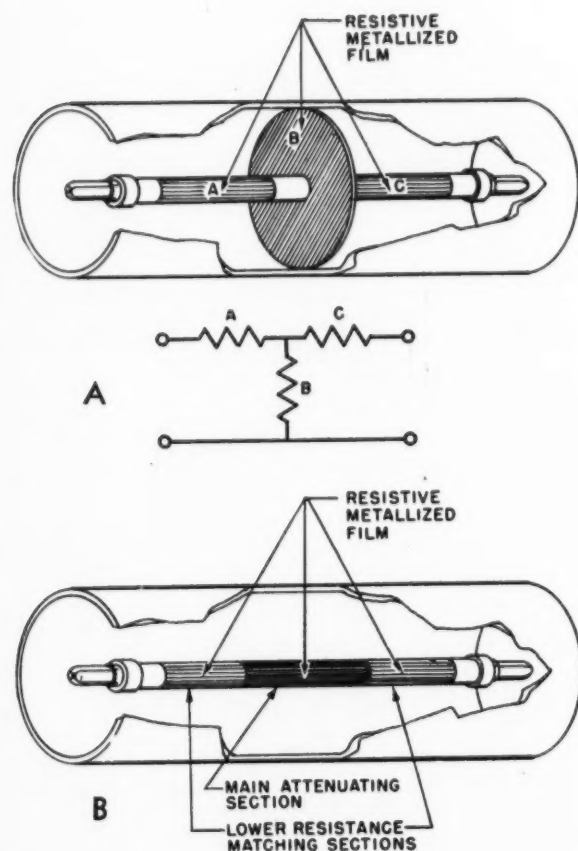


FIG. 2. BASIC TYPES OF RESISTIVE FILM fixed attenuators. The T-type attenuator at A has three separate resistive elements constructed in a standard T circuit. The distributed-type attenuator at B uses a resistive inner conductor which can be made in three sections—one at either end for matching and a main attenuating section in the center. The input impedance of both types are matched to the characteristic impedance of the line.

AN ATTENUATOR is a device that is inserted between a source of power and a load to reduce (attenuate) the amplitude of the power received at the load. Such a device has the following uses:

- (1) *Attenuation standards.* An unknown loss can be measured by comparing it with the loss produced by a standard attenuator.
- (2) *Range extension.* The range of available measuring equipment can be extended to measure higher power levels.
- (3) *Buffer pads.* The effects of mismatched impedances on such circuit elements as oscillators and resonant cavities can be isolated by attenuators. They also can be used to prevent the interaction of two components by reducing reflections.

History

Early coaxial line and waveguide attenuators were made usually with carbon as the dissipating material. In some attenuators the carbon was mixed with a binder, and the mixture used as the dielectric in the transmission line. Other attenuator types used a carbon film on a dielectric base either in series with the current flow or as a shunt across the electric field.

As the microwave art progressed, the characteristic instability and sensitivity to changes in frequency of these crude types necessitated the development of a more stable unit. The Microwave Research Institute undertook such a program as early as 1942, concentrating its research on resistive metallic films. In 1945, the Polytechnic Research and Development

Company entered into association with the institute for the design and production of metallized glass attenuators. Very thin metal films of closely-controlled thickness with protective insulating coatings rendered these devices particularly insensitive to atmospheric influences, made them electrically and mechanically stable, and provided for low temperature coefficients of attenuation.

Metallizing

The first problem in the development of the metallic film attenuators was the selection of a base material. Glass was chosen because it possesses the following desirable properties:

1. Its melting point makes it usable for most metallizing processes.
2. The surface can be made very smooth, thereby reducing the tendency for breaks in the thin metallic film.
3. It is chemically inert and does not react with the film.
4. It is not hygroscopic and will not warp or change shape.

Two metallizing techniques were considered applicable to the making of these attenuators. In one process a metallizing solution containing metal-organic compounds is spread evenly over the surface of the glass. The painted glass is then baked at a high temperature until the organic material decomposes and the resultant metallic film is embedded into the surface of the glass. In the second process, the metallic film is evaporated to a glass surface in an evacuated

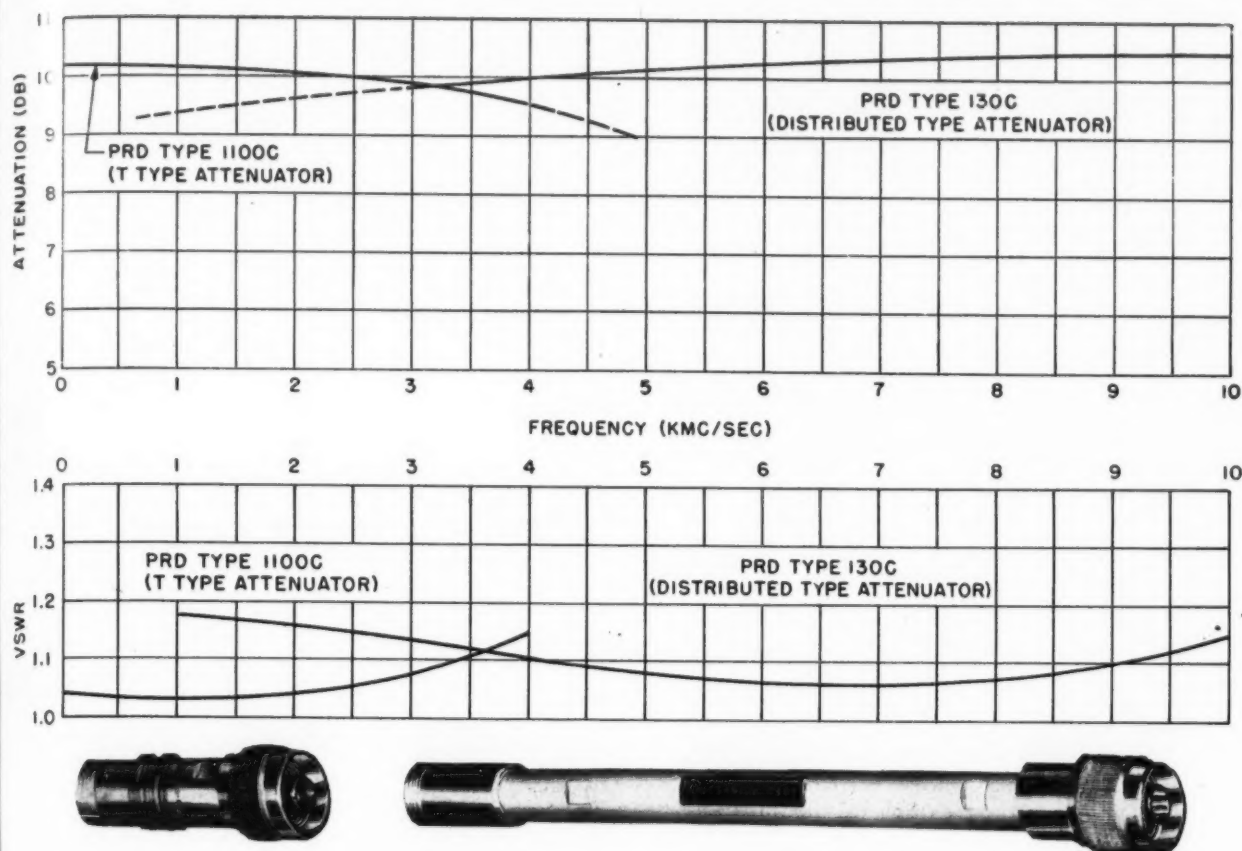


FIG. 3. COMPARISON OF THE ELECTRICAL characteristics of typical T and distributed-type fixed coaxial attenuators. Both the attenuation and voltage standing-wave characteristics show that the T-type attenuator performs best at low frequencies and that the distributed type is best at high frequencies.

chamber until the desired resistance value is obtained.

Many materials and depositing methods were tried before arriving at a satisfactory metallizing technique. A baked-on metallic film combining platinum and palladium was found to have (along with other desirable depositing characteristics) the desired low thermal coefficient of resistance. An evaporated film of either chromium or nichrome with a protective film of magnesium fluoride also was found to be satisfactory. Practice favors the baked-on film technique for coating the inner conductor of coaxial line attenuators; the evaporating technique is used predominantly for coating the flat glass inserts of waveguide attenuators.

Resistive films made by using either process are extremely thin—so thin that they are transparent. For most attenuator applications the film thickness is less than the depth of current penetration even at the highest microwave frequencies; thus the d-c resistance can be used as an accurate indication of the attenuation expected at microwave frequencies. This enables close production control in making attenuator elements.

Coaxial Line Attenuators

Two basic types of fixed coaxial resistive film attenuators are in common use (Fig. 2). The first uses

either one or more "T" sections made with lumped resistive elements. The second type uses an inner conductor of an electrically-long resistive film. Both types have matching provisions to make the input impedance equal to the characteristic impedance of the line. (This is desirable in all attenuators in order to decrease the dependence of the attenuation value upon the circuit in which the attenuator is used.)

The electrical design of a simple T-section microwave attenuator is similar to the design of audio-frequency T sections. The impedance of the T section is fixed by the characteristic impedance of the coaxial line. The maximum and minimum values of attenuation are set by the number of sections that are to be used and the available range of resistance values.

A T-section attenuator is most useful at lower frequencies (Fig. 3). The useful upper frequency is limited by the physical size of the resistors and the mechanical mount. At the higher frequencies the size of the resistive elements becomes comparable to the wavelength; a point is reached at which they can no longer be considered as lumped components. Therefore, at high frequencies it is generally more desirable to use a distributed-type attenuator rather than to modify the T section.

The characteristics of a distributed-type attenuator

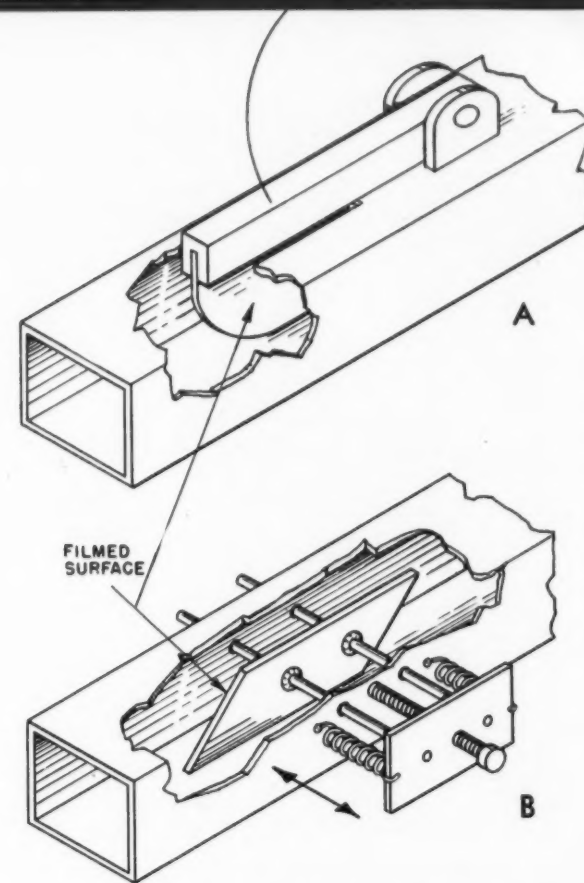


FIG. 4. MECHANICAL CONSTRUCTION OF flap-type (A) and vane-type (B) waveguide variable attenuators. When the resistive film is on a thin dielectric carrier, it is simple to vary the attenuation by moving the film to different regions in the electric field. Both attenuator types have negligible insertion losses when the film is completely out of the electric field.

also are shown in Fig. 3. The attenuation of the main section and matching sections can be predicted using standard transmission line theory.¹ It can be shown that when the attenuation per unit length is not too high, the attenuation is almost independent of frequency. Under these conditions the total attenuation, $\alpha_{(Total)}$ is approximately:

$$\alpha_{(Total)} = 0.5 r l / Z_0 \text{ nepers}$$

where r = resistance per unit length of the metallized inner conductor; l = length of the metallized inner conductor; Z_0 = characteristic impedance of a lossless line with similar dimensions.

Resistive matching sections are used on distributed-type attenuators because they are more broadband than other types, such as a simple lossless transformer. An exact design for the resistive matching section is complex because of the different propagation constants in the matching and main attenuating sections, and also because of the involved mathematics of transmission lines with loss. The factors concerned

¹H. J. Carlin and J. W. E. Griemsmann, "A Bead Supported Coaxial Attenuator for the Frequency Band 4,000–10,000 mc/sec.," *Proceedings of the National Electronics Conference*, Vol. III, p. 80-83, Nov., 1947.

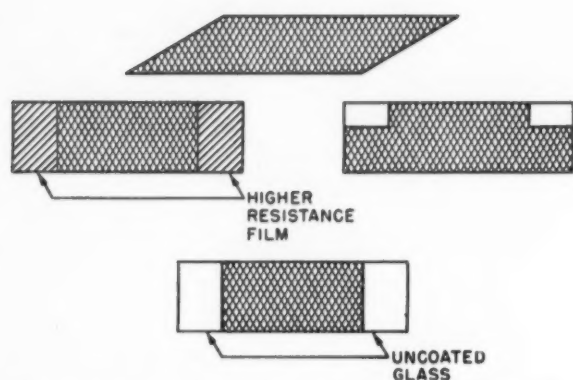


FIG. 5. BASIC WAVEGUIDE ATTENUATORS. Both the taper match in A and the resistive transformer match of B use power-absorbing matching sections. Both types provide a more broadband match than the lossless transformer match shown in C.

in the design of the matching section are the *operating frequency range*, the *attenuation rate* of the main and matching sections, and the *total attenuation* of the unit. Because the design of fixed coaxial attenuators can be treated theoretically, it has been an important factor in optimizing their performance. This, however, is not true for variable attenuators.

At the present time there are no satisfactory commercial metallized-glass coaxial *variable* attenuators. Several types have been made where sections of the attenuating center conductor are shorted out either by a movable metal tube over the outside of the film or by a metal rod on the inside of the film. None of the systems tried was considered suitable.

The power rating of most attenuator designs—coaxial and waveguide—is determined mainly by the maximum temperature that the film can withstand before fracturing. In most attenuators, the resistive section closest to the generator dissipates most of the power. The heat distribution is, therefore, uneven, and the maximum that a particular attenuator can dissipate will be determined by the electrical design of the attenuator as well as by the element itself. Of the designs currently in use, even the smallest units are able to dissipate one watt of average power. This is entirely adequate for most measurement applications.

Waveguide Attenuators

A convenient attenuator for a rectangular waveguide propagating the TE_{10} mode makes use of a resistive film parallel to the electric field lines. Two ways of doing this mechanically are shown in Fig. 4, which shows flap- and vane-type attenuators. When the resistive film is on a thin dielectric carrier it is a simple matter to vary the attenuation by moving the film to different regions in the electric field.

The vane-type attenuator (Fig. 4B) is completely shielded, whereas the flap type (Fig. 4A) is not. Although the flap type is cheaper to make, its use is limited by the leakage through the slots, which reduces the maximum attenuation attainable. In some

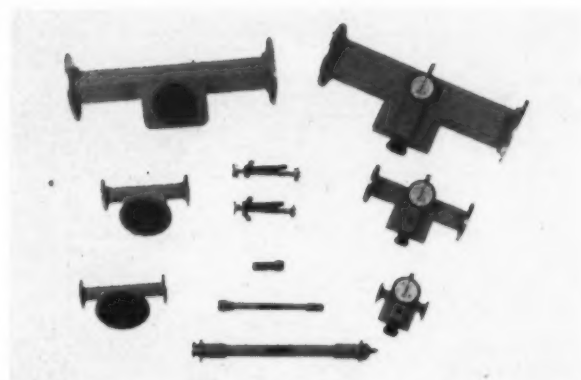


FIG. 6. THIS ARRAY SHOWS the wide range of types and sizes available in metallized film attenuators.

designs this leakage is reduced by placing absorbent material next to the slot. Both attenuator types have negligible insertion losses when the film is completely out of the electric field.

Three basic methods are available to match the attenuator to the characteristic impedance of the waveguide (Fig. 5). The exact dimensions for all of the matching sections are obtained experimentally. The blank glass and resistive transformer sections are approximately $\lambda_g/4$ long.* A good match is obtained with a taper approximately $\lambda_g/2$ long. The taper match is basic to the microwave field but is usually not the most useful because it requires more length than the others for an equivalent match. For reasonably short taper lengths (less than one wavelength) the taper match is no more broadband than the resistive transformer match. The uncoated glass transformer is a narrow-band matching section generally requiring less length than the other types. Current practice favors the resistive transformer match because of its good broadband characteristics and because evaporation to a rectangular glass plate is relatively easy.

The calculations required to theoretically determine the attenuation characteristics of a vane-type attenuator are too involved for practical use. All of the characteristics of waveguide attenuators are determined experimentally.

Conclusions

The attenuator is employed in isolation sections, in signal generators, for increasing the range of power-sensitive instruments and, because of the unusual stability of the metallized glass inserts, it can be used as a calibrated secondary standard.

Resistive metallized glass attenuators have a record of almost 13 years of commercial use. During this time, the elements have been found to be mechanically sound and electrically stable. They have replaced other dissipative types in both field and laboratory applications.

* * * * *

* λ_g is the wavelength of the lowest frequency which is passed by the wave guide.

Electroluminescence and Photoconductance Produce Flat-Panel Pix

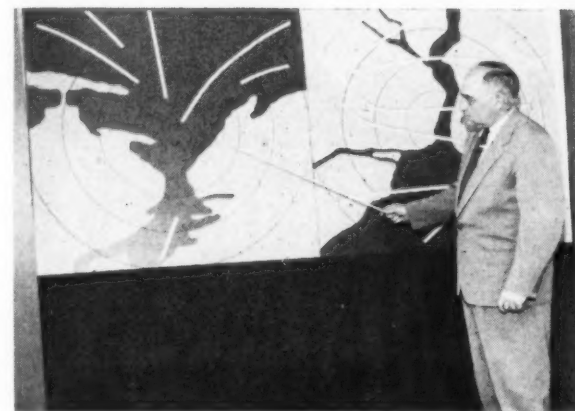


FIG. 1. THE PANEL AT THE LEFT is a simulation showing possible use as a radar "map" on which ships entering and leaving a harbor would be traced through radar signals. At right is a simulation showing how aircraft might be similarly traced.

NEW SYLVATRON* panels are an outgrowth of "Panelescent" lighting introduced six years ago. (The Panelescent "lamp" produces light by electroluminescence, by direct excitation of certain phosphors in an electric field.)

The new image-producing panels use this principle and also the principle of photoconductance, which is the influence of light on the flow of electricity through a solid. The control layers are thin coatings of these photoconductive and electroconductive surfaces.

Structure

The panels are electroluminescent 2" and 4" squares of glass or metal; larger sizes are under development (Fig. 1).

There are at present three basic types (many combinations of these types are under development):

I. An electroluminescent panel on which the position of a mobile dot of light can be manipulated electrically.

*Sylvania Electric Products, Inc., Lighting Div.

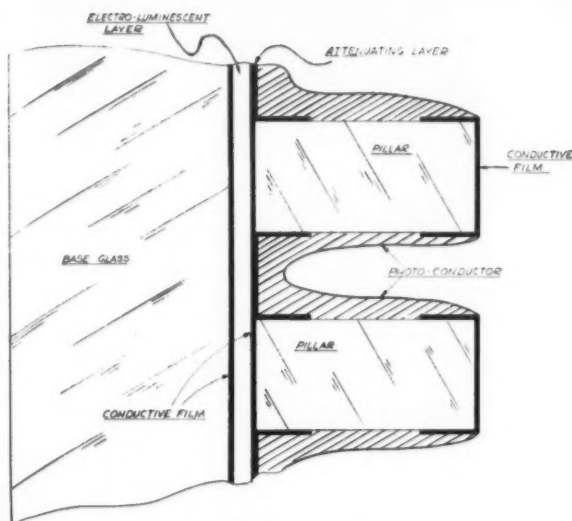


FIG. 2. THE CUT-AWAY DRAWING at the left shows the over-all layered construction on top of which are cemented sets of columns. When a-c electricity is applied to the two conductive coatings—one below the electroluminescent layer and the other on top of the conductive caps—and a spot of triggering light of short duration is applied to an individual column, either from front or back, the photoconductor transmits the electricity, and the electroluminescent dot under the column lights up.



FIG. 3. THE LIGHTED SQUARE and the letter "H" in the photograph are images which have been reproduced optically on a flat panel.

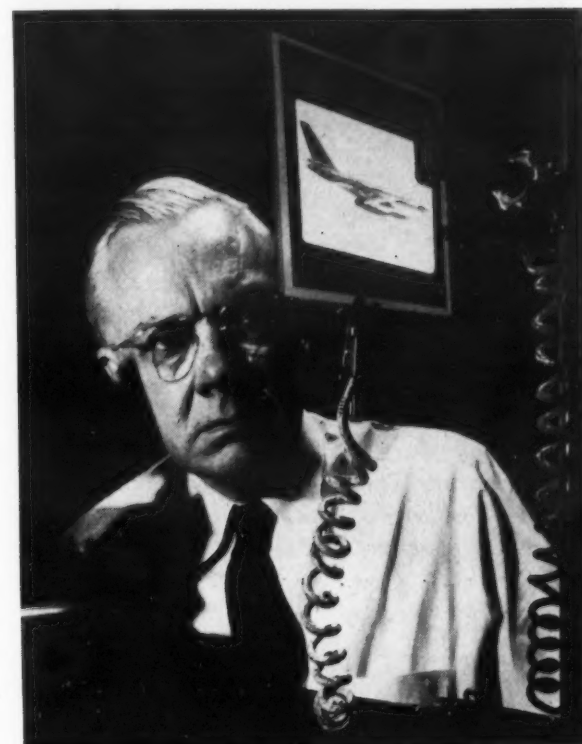


FIG. 4. THE IMAGE-PRODUCING PANEL is shown being put through laboratory tests.

II. A display panel which reproduces optically the track of a mobile spot of light. The image thus created from Type I. A piece of conductive glass has an electroluminescent coating. On top of this are cemented sets of photoconductor columns approximately $1/32''$ square with a $1/32''$ spacing to adjacent columns. This presents a "waffle iron" effect (Fig. 2). Black glass is applied to the webbing between individual columns. Each column has a conductive cap on both top and bottom. A top conductor of perforated metal mesh or conductive glass is then cemented across the top conductive caps of the columns joining them together.

When a-c power is applied to the two conductive coatings—one below the electroluminescent layer and the other on top of the conductive caps—and a spot of triggering light of short duration is applied to an individual column, either from front or back, the photoconductor transmits the a-c power and the electroluminescent dot under the column lights up (Fig. 3). The feedback of this light into the column is sufficient to keep the photoconductor active so that the dot remains lit even after the triggering light is shut off. The black webbing prevents adjacent dots from lighting. Each dot will remain dark until triggered, and will remain lit after triggering. The dot can re-

main lighted from a fraction of a second to a number of hours, as desired.

Sylvatron Type III is a flat screen; it consists of a conductive glass square coated with an electroluminescent layer, a photoconductor layer and an electrically conductive layer. By applying a-c power to the conductive layers and by applying or projecting a light image or picture to the back of the screen, the image ated can then be held or "stored" indefinitely in visible form on the panel.

III. An electroluminescent panel which can reproduce optically a motion picture with good resolution and rapid response.

Sylvatron Type I is a flat plate; it consists of a glass or metal square alternately coated with horizontal conductive strips, an electroluminescent layer, and vertical conductive strips. The strips are about $3/64''$ wide with an insulating gap of $1/64''$ between strips.

A 2" square would thus have 32 contacts horizontally and 32 vertically. By connecting a-c power to any horizontal contact and to any vertical contact, the square at the intersection becomes brightly luminescent, appearing as a "pip" of light. Thus, any one of the 1,024 squares can be lit individually.

Sylvatron Type II is a display panel, a light storage device which has a slightly different construction

or picture, consisting of thousands of dots of light, is reproduced on the front (Fig. 4).

In its present state of development, this Type III device is a frequency converter, changing red or infrared light into blue or green light.

Combinations

Combination of these three types lend themselves to certain applications.

Sylvatron Type 12 is a combination of Types I and II which can convert electrical data into "pips" of light, or a track of light, and store this resulting light combination, which could be numbers, letters, or pictures.

Sylvatron Type 13 is a combination of Types I and III which could electronically (as opposed to optically) reproduce motion pictures.

Frank J. Healy, vice president in charge of Sylvania's lighting operations, said the company is "restricting our attention to national defense applications and relatively specialized commercial and industrial fields. Exploratory work in any other fields will have to take a back seat for quite some time—and I am talking in terms of years. As far as television, specifically, is concerned, there will be no application of Sylvatron in the foreseeable future".

For more information on Sylvatron Panels circle 206 on inquiry card.

SERVOS—NO. 3

In preceding articles of this series, basic principles and equations governing servo systems have been presented. This article introduces an important family of servo components—synchros—showing their use in open- and closed-loop servo systems.



Fig. 1.

MILITARY TYPE SYNCHRO NUMBERS

Control Transformers—CT

11CT4a-26V • 11CT4a • 15CT4a • 16CTB4a • 18CT6a • 18CT4a • 19CTB4a • 19CTB6a • 1HCT • 1HCT-400 cps • 5HCT • 23CT6a • 3'-23CT6a • 23CT6 • 3'-23CT6 • 23CT4 • 3'-23CT4 • 23CT4a • 3'-23CT4a • 23TR6-CT6

Control Transmitters—CX

11CX4a • 11CX4a-26V • 15CX4a • 16 CXB4a • 18CX6a • 18CX4a • 19CXB4a • 23CX6a • 3'-23CX6a • 23CX6 • 3'-23CX6 • 23CX4 • 3'-23CX4 • 23CX4a • 3'-23CX4a

Control Differential Transmitters—CDX

15CDX4a • 18CDX4a • 18CDX6 • 23CDX6a • 23CDX6 • 23CDX4 • 23CDX4a • 5HDG

Torque Transmitters—TX

15TX4a • 15TX6a • 18TX4a • 18TX6a • 1HG-400cps • 5HG • 23TX6a • 23TX6 • 23TX4a • 23TX4 • 31TX6 • 31TX4a • 31TX6a

Torque Differential Transmitters—TDX

15TDX4a • 18TDX4a • 23TDX6 • 23TDX6a • 23TDX4a • 23TDX4 • 31TDX4 • 31TDX6

Torque Receivers—TR

1F • 15TR4a • 15TR4b • 15TR6a • 18TR6a • 18TR4a • 19TRB4a • 23TR6 • 23TR6a • 23TR4 • 23TR4 ("T" shift) • 23TR6-CT6 • 31TR6 • 31TR4c • 31TR4a • 16TRB4 • 31TDR6 • 31TDR6

Table 1

SYNCHROS

KENNETH L. KING Norden-Ketay Corporation
CLAUDE O. MORRISON Military Automation

SYNCHROS are angular positioning devices which are essentially transformers with one winding free to turn within the field of the other. Synchros are known by a number of trade names: Autosyn (Bendix), Diehlsen (Diehl), Selsyn (General Electric), Telegon (Kolsman), Magslips (Muirhead), etc. Others, including Norden-Ketay, Kearfott, Clifton Precision Products Co., etc. use the term *synchro*. The specific functional designations given in Table 1 are standard with the Armed Services. Synchros are broadly classified for either *torque* or *control*, and further classified functionally as transmitter, receiver, differential, and transformer (Table 1). The electro-mechanical function to be performed by a particular synchro determines its specific design. The torque synchros are designed to deliver the maximum me-

chanical torque gradient consistent with heat dissipation and size, while the control synchros are generally used in closed-loop ("feedback") servo systems to achieve maximum accuracy by furnishing an output voltage proportional to angular error.

Synchro Torque Open-Loop Systems

In its simplest form, a *synchro torque system* consists of a synchro torque transmitter (TX) and a synchro torque receiver (TR). These two elements are practically identical in construction (Fig. 2), differing chiefly in that the receiver is electromechanically damped. Each has a 3-phase-type* winding on

*"Three-phase type" refers to the connection of coils spaced 120° apart on the frame. The voltage induced in all windings are always in phase with the single-phase input.

its stator and a 2-pole winding on its rotor (Fig. 3). The two rotors are connected directly to the same single-phase source of alternating current, while the two stators are connected by a three-wire line so that each terminal on the TX stator is connected to the corresponding terminal on the TR stator. No electrical connection exists between stator and rotor.

A simplified diagram of a synchro torque system consisting of a single torque transmitter and two torque receivers is shown in Fig. 4. Displacement of the transmitter rotor to a position x will cause electrical unbalance of the system. The resultant current

FIG. 2. CUTAWAY view of torque transmitter (TX).

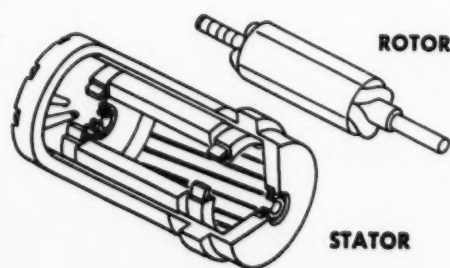


FIG. 3. SCHEMATIC DIAGRAM of an open-loop synchro system consisting of one TX and one TR.

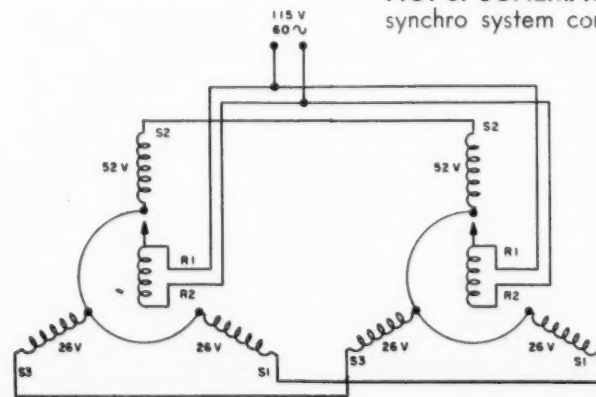
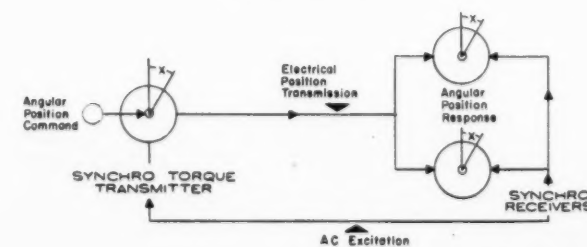


FIG. 4. SIMPLIFIED SCHEMATIC of one TX driving two TR's to provide position indications to two separated observers.



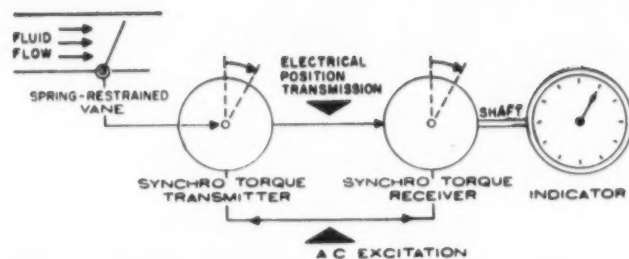


FIG. 5. FLUID FLOW remote indicating system.

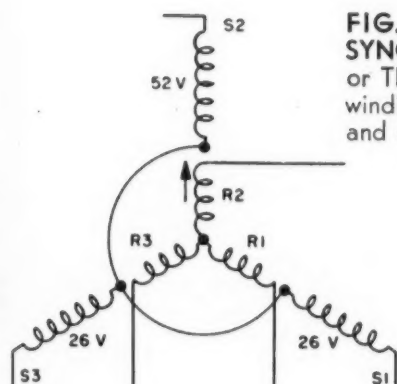


FIG. 6. DIFFERENTIAL SYNCHROS (CDX, TDX or TDR) have three-phase windings on both rotor and stator.

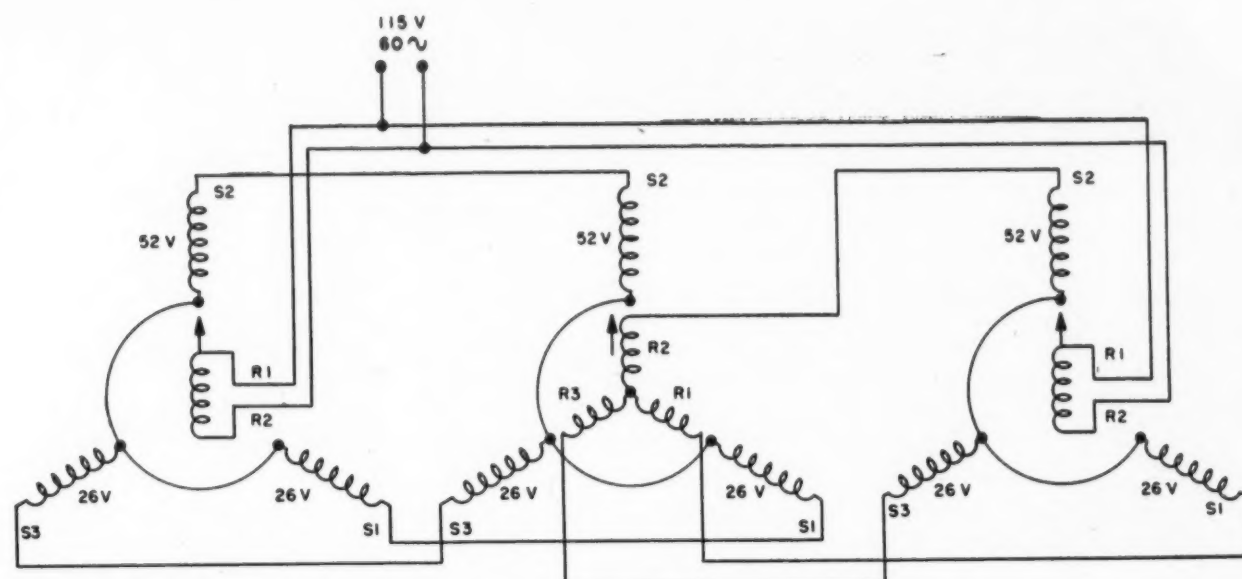


FIG. 7. TDX (differential transmitter) has no a-c line connection.

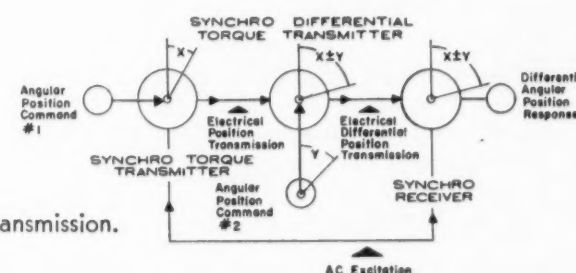


FIG. 8. DIFFERENTIAL data transmission.

flowing in the stator circuit provides a torque proportional to the sine of the angular difference in position of the transmitter rotor and the receiver rotor. This torque rotates the receiver rotor until it assumes the same angular position as the transmitter rotor.

(Although torque is developed at both the TX and TR, the controlling device prevents free motion of the TX rotor.)

The torque output of the receiver per degree of system error (about the null) is defined as the *torque gradient*. The higher the torque gradient, the less the error introduced by friction in the system. If a receiver has a friction torque of x (oz in) and a torque of ax (oz in) per degree, the resultant error can be seen to be $1/a$ degrees.

A simple example of a data transmission system (Fig. 5) consists of a synchro transmitter controlled by a spring-restrained vane actuated by fluid flow. The transmitter shaft position varies with the flow. This shaft displacement causes the current through the stator to develop a proportional torque that rotates the shaft of the remotely located synchro receiver to a position corresponding to the transmitter shaft. The receiver shaft is coupled to a pointer that indicates the flow on a calibrated dial.

The simple torque synchro system has no amplification of power, for if both rotors are held in non-corresponding positions, both rotors will develop the same torque. In effect, the torque synchro system acts

like a long flexible shaft which will accurately transmit angular position over a distance of several hundred feet. At greater distances, or when more output power or greater accuracy is required, servo amplifiers and servo motors must be added to the system.

Synchro Differential Transmitter (CDX or TDX)

Addition or subtraction of angles is important to a naval officer when conning a ship or directing gunfire. A gyro compass indicates true-bearing headings, but lookouts and gun crews work from relative bearings. Bearings on the ship's radar scope in the Communications Information Center (CIC) are customarily indicated in true bearings but may require instant conversion to relative bearings for liaison with the gunnery officer. It is important that this conversion be always accurately and instantaneously available. The synchro differential transmitter is the device which makes this possible.

A torque receiver can be positioned to the algebraic sum of the two independent inputs, one from a standard TX, and the other from a torque differential transmitter (TDX). The output of the TR will then be a position angle indication which can be either the sum or the difference (depending on the linkage connection) of the two transmitter inputs.

The synchro differential transmitter (either torque or control type) has a three-phase-type winding on its rotor as well as on its stator (Fig. 6). The differ-

ential transmitter can be identified by 3 signal input and 3 signal output leads. No connection to the ac power supply is used (Fig. 7). In its electrical zero position the synchro differential functions as a 1:1 transformer and so has no effect on the transmitted signal. However, if a second controlling device displaces the shaft of the differential transmitter, a correction will be added to, or subtracted from, the transmitted signal (Fig. 8). The use of differential synchros permits the continuous display of relative bearing information at the scope of a search radar which normally shows true North at the top of the scope regardless of ship's heading.

Control Synchros—Closed Loop Systems

The applications given above have been of open-loop synchro systems where the greatest precision is not required. As previously stated, closed-loop systems are employed whenever greater precision is required or where the power output needed is so great that amplifiers must be introduced between the input and output stages. Although torque synchro elements could be used in a control system, greater accuracy is achieved through the use of specially designed units engineered for precise information output rather than for power transmitting efficiency.

In a closed-loop system (Fig. 9), the control transmitter (CX) is mechanically coupled to the positioning control device and is electrically linked to a con-

control transformer (CT), which also is mechanically coupled to the controlled device. The control transformer does not produce an output torque, but an output voltage proportional to the error between its shaft position and the transmitter shaft position. This output voltage is amplified and used to control a servo motor driving the controlled device. In this way, the position of the controlled device is accurately controlled, any error being fed back and producing an electrical output which is used to correct the existing error. As the synchros in a closed-loop feedback system are not required to produce any torque, friction error is reduced, with a consequent increase in accuracy.

Differential synchros also can be used in closed-loop systems. An example, shown in Fig. 10, is a differential system using control synchro elements to elevate a ship's gun. In this instance, the "command order" calls for a 70° angle from the zenith. However, the fire-control level gyro indicates a 5° pitch angle in the vessel's attitude at the moment. The 70° command order is fed electrically to the rotor of the CDX. At the same time, the 5° gyro deviation is fed mechanically to the rotor of the CDX, which makes a 5° turn in relation to the stator, leaving a net command order of 65°. A signal corresponding to this net command is then transmitted to the stator of the synchro control transformer, (CT) which has its rotor position synchronized with and controlled by the elevation angle of the gun. If the gun is at the 65° angle, the CT will have zero output. If it is at 60° from the zenith, a single-phase electrical signal leading the ship's supply voltage by 90° will be fed into the control amplifier. The amplified signal, combined with the ship's reference voltage, then produces a two-phase input to drive the servo motor which lowers the gun. If the gun's position had been 70°, instead of 60°, the output signal from the CT would have been the same amplitude as before, but would have lagged behind the ship's supply voltage by 90°, thus reversing the phase of the signal input to the servo motor, and its direction of rotation.

Forthcoming articles of this series will discuss refinements in servo system design.

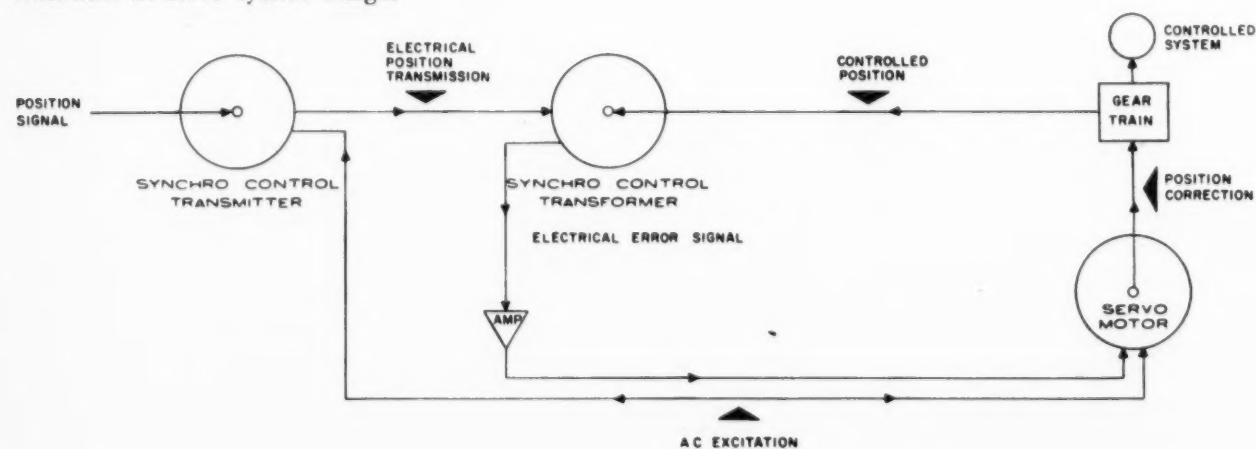
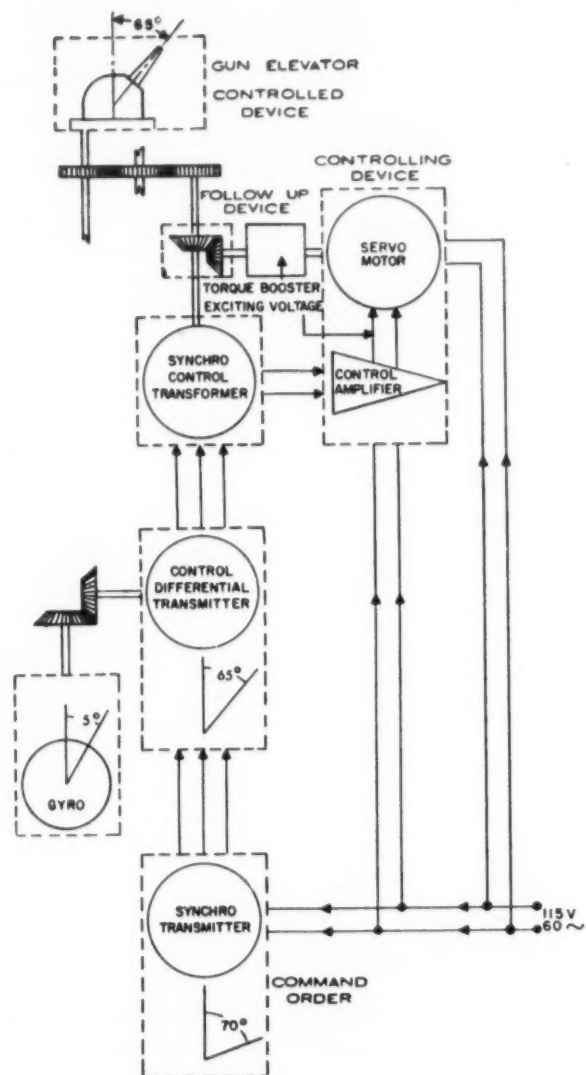


FIG. 9. CLOSED-LOOP AUTOMATIC control system provides high accuracy; there is no limit on power.

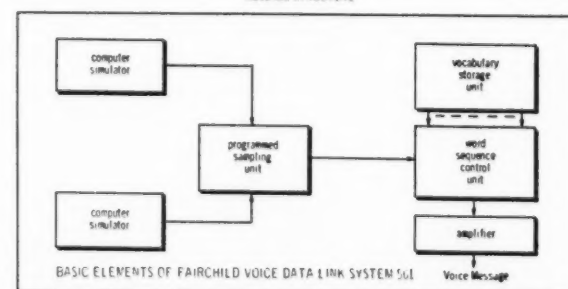
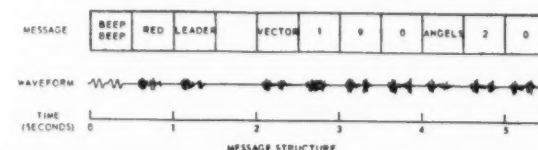
FIG. 10. SIMPLE DIFFERENTIAL elevation servo system for naval gun.



Multilingual Automation

CONTROL tower to pilot communications, so vital during the approach and landing phase, are seriously complicated in international traffic when the pilot and tower personnel do not know each other's language. Although the pilot's end of the conversation can be handled by phonetic stereotyped phrases, the return instructions to the pilot require accurate understanding of numbers, headings and other varied details. These details can now be transmitted in the pilot's own tongue by automatized techniques using new Voice Data Link System developed by the Electronics Division of Fairchild Controls Corporation.

The vocabulary storage unit contains all the pre-recorded words necessary to command a plane on an intercept mission. These words may be available in as many languages as desired. Basic message formats are set up within the system so that computer or manual control signals are required only for the variable portions of the message. The system can also provide for the simultaneous transmission of more than one message over individual audio channels.



Important military uses are seen for this development at smaller NATO and other allied airfields where linguistically-trained control tower operators are not always available. Other applications include information directories in airline and railroad terminals, docking and mooring instructions to foreign vessels in harbors and airborne early warning. It also is adaptable to military training simulators.

For more information on Voice Data Link System circle 207 on inquiry card.

Spacistor

THE Spacistor, a semi-conductor device as tiny as a transistor, operates electrically like a vacuum tube. Still in the research stage, the new device promises to amplify at frequencies up to 10,000 megacycles, as much as 50 times higher than transistors. Also, because Spacistors can be made from materials unsuited for transistors, they are expected to operate at temperatures as high as 500°C, more than double that for today's germanium or silicon transistors.

Invented after two years of intensive research by Raytheon Mfg. Co., the Spacistor may require three to five years of more research and development before it becomes commercially available.

Operation

Carrier motion across the base region of a transistor is slow because this region is essentially field-free. Although the base region of a diffused transistor has a built-in field, its strength is severely limited.

Very much higher field strengths are found, however, in space-charge regions in reverse-biased junctions; in fact, field strength is limited only by the breakdown voltage of the semiconductor body. The Spacistor uses these high-strength fields to accelerate the charge carriers so that their transit time is greatly shortened (Fig. 1).

Modulator *M* has two functions. First, it varies the emission of injector *I* by superimposing an a-c voltage on the d-c bias. The field produced by *M* penetrates throughout the space-charge region to its boundaries.

The second function of modulator *M* is to make the bias of injector *I* practically independent of the voltage applied across *B-C* so as to keep the output impedance desirably high—in excess of 30 megohms for an injected current of 0.3 ma.

Expected Improvements

Transconductance (g_m) of present experimental Spacistors is considerably below that of good vacuum tubes, but with further development it is expected that comparable values will be attained.

A low-frequency power gain of 70 db has already been achieved with experimental Spacistors at low frequencies. A comparable advantage over transistors is expected to be realized at higher frequencies as well. When the present input of 30 megs is improved, power gain will become so great that it will be more appropriate to talk about voltage gain as in the case of a vacuum tube. A voltage gain of 3000 already has been achieved.

Input and output are decoupled to a high degree as in a vacuum tube—a useful property in the design of multi-stage circuitry.

Another important advantage of the Spacistor is that its operation is practically independent of charge-

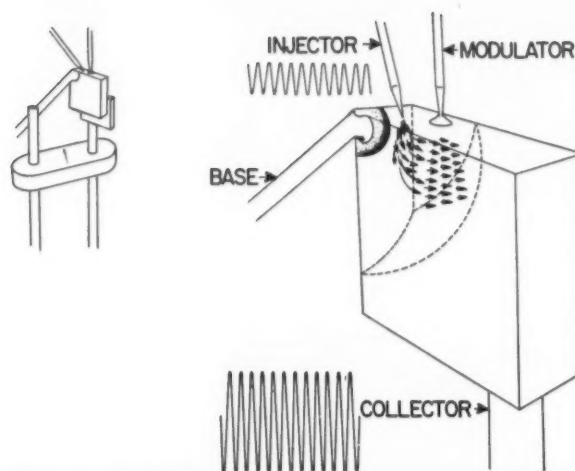


FIG. 1. THE SPACISTOR. A voltage is applied between base and collector to produce a high electric field but virtually no current. Electrons enter the high field from the injector and flow rapidly to the collector contact. This flow is modulated by the signal on the modulator, which draws little current.

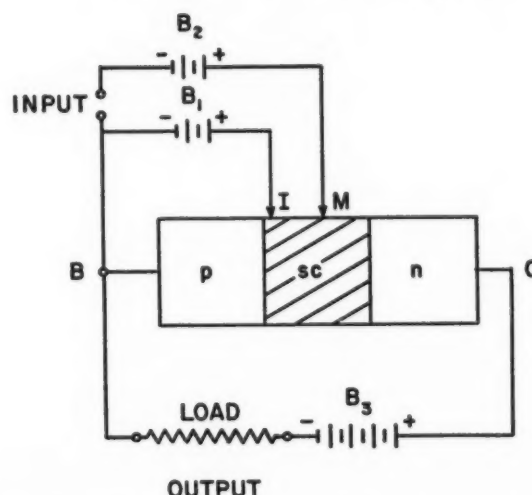


FIG. 2. TYPICAL experimental Spacistor and external circuits.

	VACUUM TUBE	SPACISTOR	TRANSISTOR
FREQUENCY LIMIT	HIGH (1,000 Mc)	HIGH (10,000 Mc)	MEDIUM (250 Mc)
HEATER POWER	REQUIRED	NONE	NONE
HIGH TEMPERATURE MATERIALS	AVAILABLE	AVAILABLE	NOT AVAILABLE
THEORETICAL LIFE	LIMITED	UNLIMITED	UNLIMITED
VACUUM ENVELOPE	REQUIRED	NONE	NONE
CIRCUIT WEIGHT AND SPACE	HIGH	LOW	LOW
STRATEGIC MATERIALS	REQUIRED	NONE	NONE
COMPLEXITY OF MULTIPLE-STAGE CIRCUITRY	LOW	LOW	HIGH
INPUT AND OUTPUT IMPEDANCES	HIGH	VERY HIGH	LOW

carrier "lifetime." It should therefore be feasible to employ not only germanium and silicon but also other semiconductor materials whose short "lifetime" makes them unsuitable for transistors. Silicon carbide and other materials with large energy gaps are promising possibilities for high-temperature Spacistors.

For more information on Spacistors circle 208 on inquiry card.

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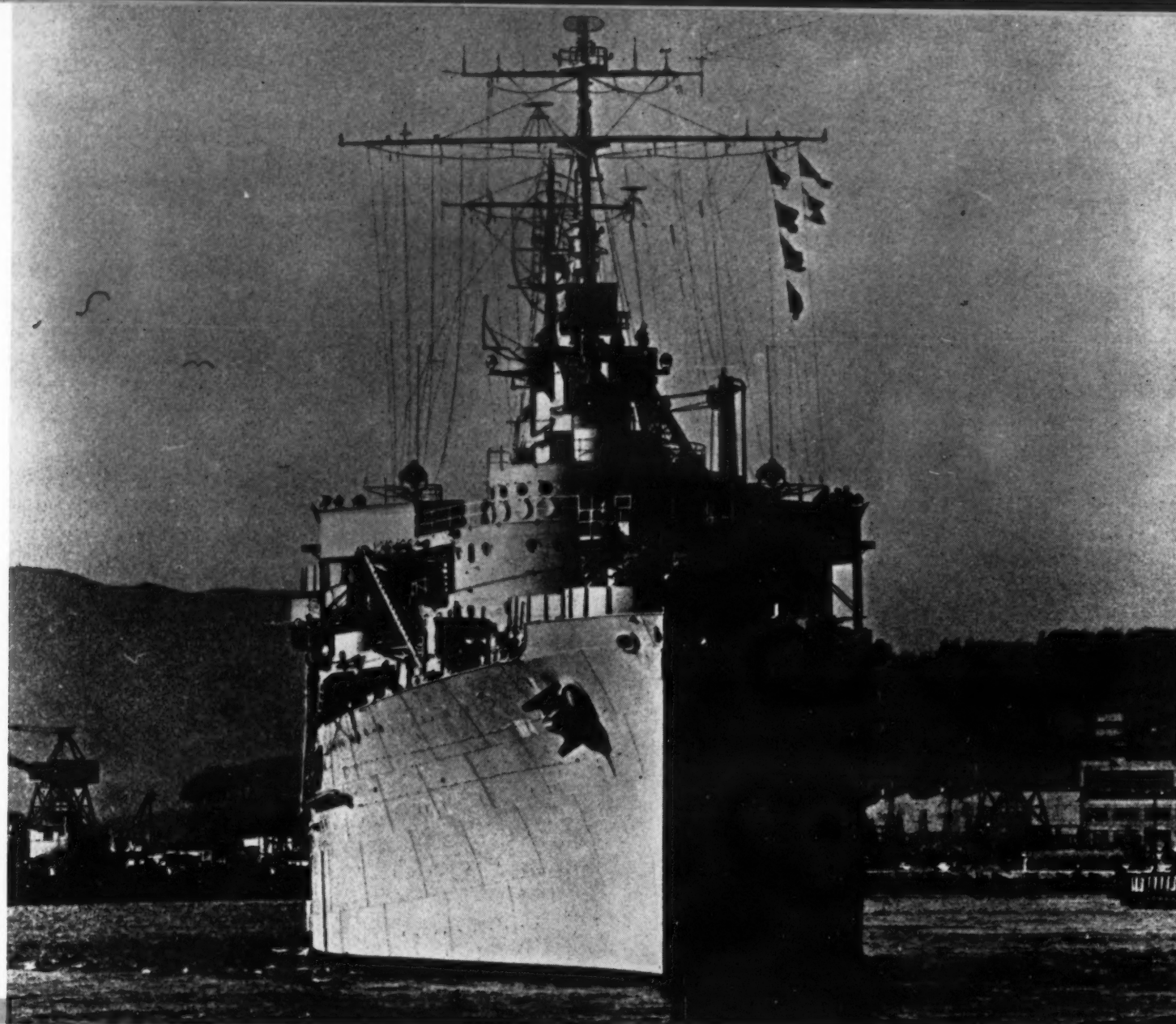
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FIG. 1. USS CURTISS AV-4, now carries radiometric inertial equipment similar to that described here.



Radiometric Inertial Reference

Victor W. Bolie
Collins Radio Co.
Cedar Rapids, Iowa

The sextant has been the basic navigation aid since antiquity. Now a radio sextant sun-tracking radiometer sees through clouds to correct long-term drift of stabilizing gyros and provide accurate position information.

ACCURACY in navigation has long been an aim of mariners, if for no other reason than avoiding charted rocks and shoals and for estimating time of arrival at the next port. Optical observation of the altitude angle above the horizon of accurately-charted celestial bodies, including the sun, moon, planets, and some fixed stars, has been the basic navigational aid

since antiquity, and has provided reasonable accuracy during periods of good visibility. Positions plotted at the time of observation are advanced on the navigator's chart by dead reckoning until the next direct observation, which might be delayed hours or days in bad weather. The basic defect in such optical celestial navigation is in its dependence on good visibility.

Many electronic methods of long range navigation such as LORAN, are in general use to supplement celestial navigation techniques. However, these depend on external services, and do not provide accurate positions in certain areas of the globe.

Radiometric inertial navigation, a new navigational principle initially developed by the Collins Radio Com-

pany is now being evaluated on the naval seaplane tender USS Curtiss (Fig. 1). The equipment used on the Curtiss is similar to, but not identical with, the equipment described in this article.

The newly-conceived system is an automatic all-weather tracker of the sun and moon, which homes on radio-frequency noise signals generated by those bodies. It uses a gyro-stabilized microwave radiometer suspended in a lock-free gimbal mount which is completely divorced from vehicle motion, navigation geometry, and vertical and north references. A pendulum and compass are used only in the readout of the altitude and azimuth of the antenna axis.

Basic research on "galactic" radio noise has been accomplished only since WW II. These microwave signals, although relatively weak and fluctuating in a random fashion, have a considerable component in the 2-cm wavelength region. Fortunately, this frequency readily penetrates thick clouds, and small, highly directive antennas are easily constructed for its reception. These factors make the automatic-tracking radiometer feasible.

Information theory has established the fact that a radiometric receiver having a conventional noise figure (16) and bandwidth (10 mc) and a relatively small antenna (24") can supply information at a rate which is more than adequate for maintaining an inertial reference line with available gyros.

Celestial Parameters

The axis of the earth is tilted from the normal to its orbit by an angle approximately $23\frac{1}{2}^\circ$ about the line extending to the vernal equinox (Fig. 2). The earth orbit angle changes through 360° /year due to the

motion of the earth in its orbit. Also, as the earth rotates on its axis, the observer is carried around a parallel of latitude. From the observers viewpoint, the sun has an azimuth angle α (referred to meridian north) and an altitude angle β (referred to the horizon) which vary continuously according to the following well-known equations that have been developed for optical navigation:

$$\sin \beta = \sin L_s \sin L_p + \cos L_s \cos L_p \cos \gamma \quad (1)$$

$$\sin L_s = \sin L_p \sin \beta + \cos L_p \cos \beta \cos \alpha \quad (2)$$

$$\sin \alpha \cos \beta = \sin \gamma \cos L_s \quad (3)$$

When L_p is the latitude of the observers position, L_s is the declination of the sun and γ is the local hour angle of the sun.

The first of the foregoing equations is the one that is tabulated in navigation tables to establish a line-of-position from a timed measurement of the altitude β . Equations 2 and 3 could be used to establish an intersecting line-of-position from the same heavenly body by a simultaneously timed observation of its azimuth angle α . However, because the best compasses are accurate only to approximately ± 6 minutes of arc, a technique using elaborate tables and only taking accurate altitude-derived line-of-position measurements on separate celestial bodies has been used extensively in navigation practice because a horizon reference can be established more accurately with a sextant. The same tables can be used with the radiometric tracker which uses a pendulum to establish a vertical reference accurate to ± 1 minute of arc. This pendulum will be discussed later.

The Radio Sextant

For marine navigation, a microwave sun-tracker should have dynamic balance and ability to track through high elevation angles and should use the radiometer signal only to correct for the relatively slow drifts of a pair of antenna-stabilizing gyros. Such a design is shown in Fig. 3. The four gimbal axes intersect at a common point at the center of gravity of the suspended mass, which is therefore in neutral equilibrium. The base of the mount is rigidly secured to the deck. The radiometer receiver is enclosed in the spherical enclosure, to minimize unsymmetrical wind-load torques, and also to minimize the over-all dimensions. The transparent portion of the sphere serves as the antenna radome. Because the direction of the antenna axis will be held nearly fixed with respect to a celestial coordinate system, the ship, in effect, moves around the radiometer which is fixed in space; the suspended mass will never require appreciable angular acceleration. Consequently, all four of the servo motors and their amplifiers need supply only a small amount of power to correct for the slow gyro drift.

The outer (first) gimbal ring (Fig. 4) faces the average train (relative azimuth) angle of the sun (or moon). The second gimbal ring faces the average elevation (relative altitude) angle. Neither of these two gimbal rings is permitted to move very fast with respect to the mounting base. An exception to this is when the ship is turning, in which case the train angle may be directed differentially from compass signals. Rapid rotation about the third and fourth axes are permitted, to accommodate pitch, roll, and yaw mo-

FIG. 2. ORBIT OF THE EARTH.

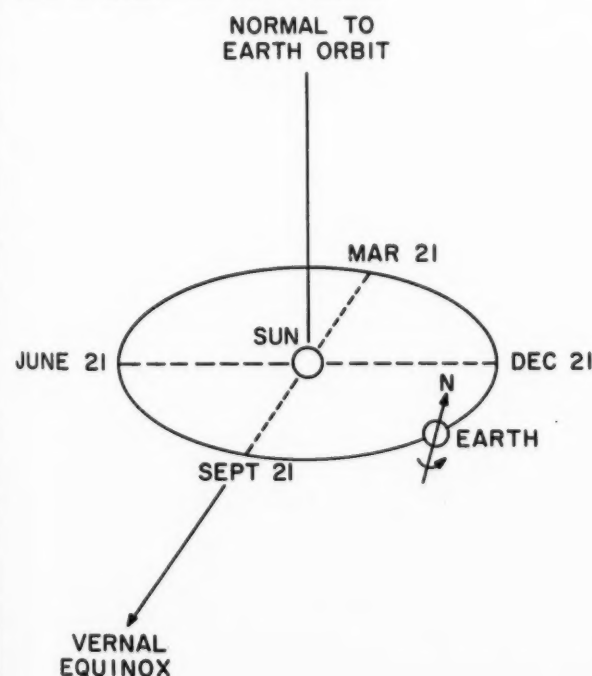
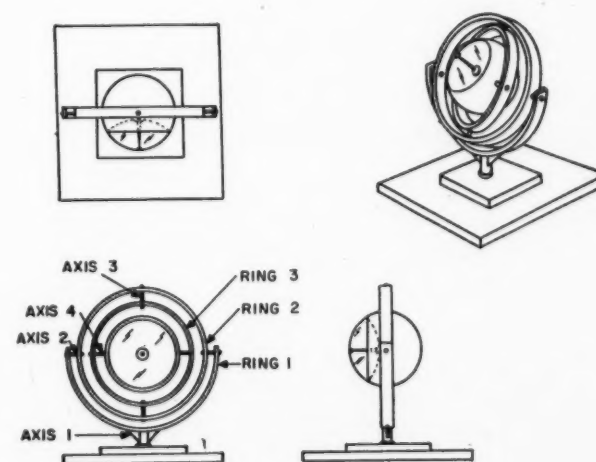


FIG. 3. RECEIVING ANTENNA is on gyroscopically stabilized platform. Antenna is rotated to automatically track sun.



FIG. 4. RADIOMETRIC INERTIAL reference mounting system for rotative sun-tracking antenna.



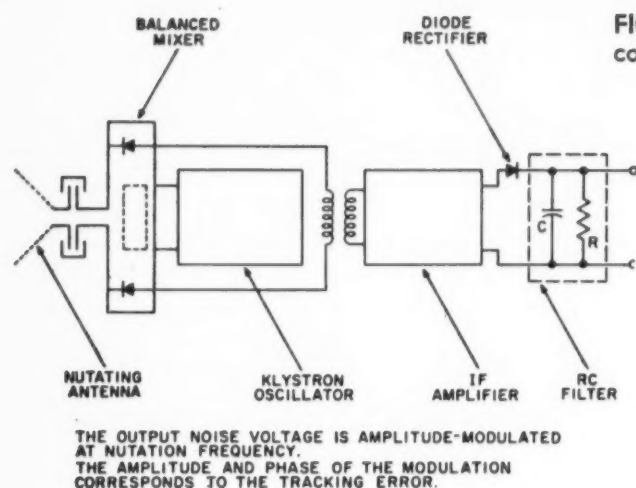


FIG. 5. MICROWAVE RADIOMETER circuit is conventional.

tions of the vehicle. A servo motor is fitted to each of the four axes to supply necessary torque.

The input to the servo motor amplifier for the second axis is the signal from a pick-off on the fourth axis, averaged over many cycles of pitch, roll and yaw motions. The second gimbal ring is therefore positioned so that the average position of the plane of the third gimbal ring is perpendicular to the antenna axis. The input to the servo motor amplifier for the first axis is the signal from a pick-off located on the third axis, averaged over many cycles of pitch, roll, and yaw motions and also corrected by a secant multiplier (potentiometer circuit) which is driven from the second axis. The outer yoke (first gimbal ring) is therefore always positioned so that the average position of the plane of the second gimbal ring coincides with the average position of the plane of the third gimbal ring. In this manner the fourth axis is always perpendicular to the antenna axis and also the average position of the third axis is perpendicular to the antenna axis, giving good universal action.

Gyro Stabilization of Line of Sight

Once set on a line of sight, the antenna axis can be held in alignment by the gyros installed in the enclosure and the servo motors at the four axes described above. One pair of highly sensitive rate-integrating gyros is supplemented by another pair of rate gyros to guarantee the absence of tracking oscillations during the heaviest weather. A gyro system alone, however, is subject to slow drift. The correction of this defect is the purpose of the radiometric receiver. Also, the line of sight from any point of earth to the sun will rotate $360^\circ/365^\circ$ (0.986°) per day, while the earth-to-moon line rotates 13.2° per day. For accurate use of navigational tables, this factor must be included in the observation.

The action of the radiometric receiver is shown in Fig. 6.

If the sun is not exactly in the center of the solid angle described by the line of sight of the nutating antenna (Fig. 5), the output noise voltage will be modulated at the nutation frequency. This noise output is fed into a resolver which has the position of its rotor synchronized with the antenna nutation. The resolver separates the noise signal into vertical and horizontal components which provide the information for correcting the drift of the stabilizing gyros through the two tracking servos, each consisting of the elements shown in Fig. 6.

The rate gyros, rate-integrating gyros, and the asso-

ciated servo amplifiers are small-size, 400-cycle aircraft type. Two of the four servos are of the simple positioning type, and position the first (outer yoke) and the second gimbal rings. They are slow acting and are designed to keep the average positions of the plane of the second gimbal ring, the plane of the third gimbal ring, and the face of the antenna parallel to each other. The third and fourth servos (supplying torques about the third and fourth axes) are identical to each other and operate independently of the first and second servos. As shown in Fig. 6 one phase signal of the radiometric receiver signal is averaged with the corresponding rate-integrating gyro and this sum is then amplified and fed to the appropriate torque motor. The torque motor acts against the combined inertia of the suspended mass and driving gear trains to rotate the apparatus. Although this action is independent for train and elevation angles, the servo equation given applies to both axes of rotation. The amount of damping and sensitivity can be adjusted readily by appropriate adjustments in the summing network parameters.

Non-random drifts of one model of rate-integrating gyro is in the order of 0.05 degrees per hour. 12 hours of operation with neither sun nor moon above the horizon would give a minimum drift of approximately 0.6 degree. When searching and locking on, a signal-to-noise ratio in excess of 15 db is attained if the scan rate does not exceed $80^\circ/\text{sec}$ for the sun or $0.1^\circ/\text{sec}$ for the moon.

The time required to stabilize on a line of sight depends on the initial displacement and the receiver's time-constants for the heavenly body being tracked. In the case of the sun, this equipment should narrow an initial error of 1° to less than one minute of arc in thirty seconds. A longer time is required to stabilize on a moon track.

To read out altitude angle (β) a pendulum is mounted within the receiver enclosure, as shown in Fig. 7. The pendulum support is rotated about the line of sight to be maintained in an average level position by a small leveling servo of slow response. Another instrument servo is used to cause a gear train and a two-speed synchro assembly to align its input so as to null the elevation pendulum pickoff signal. The acceleration effects on the pendulum of ship motions in pitch, roll and yaw are averaged out by the damping of the pendulum and servos. However, if the average position of the axis of the pendulum is not horizontal, the indicated elevation can be in error. However, if this average is within $\pm 1^\circ$ of its correct position, the error in elevation angle β will be less than 0.3 minutes of arc. Also, the azimuth angle can be read quite accurately when the true north is accurately known. The average position of the mounting base must in this case be level to within 2 or 3 degrees of horizontal. If this is assured, the maximum error in azimuth for an elevation β of 30° will be only $\pm 1^\circ$. This error will be greater for larger elevation angles.

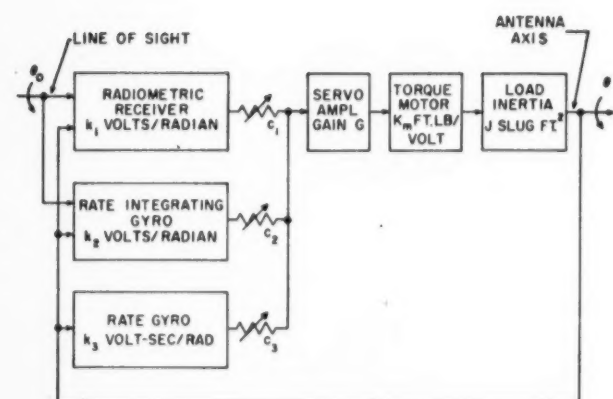


FIG. 6. TRACKING SERVO uses rate gyro and rate integrating gyro.

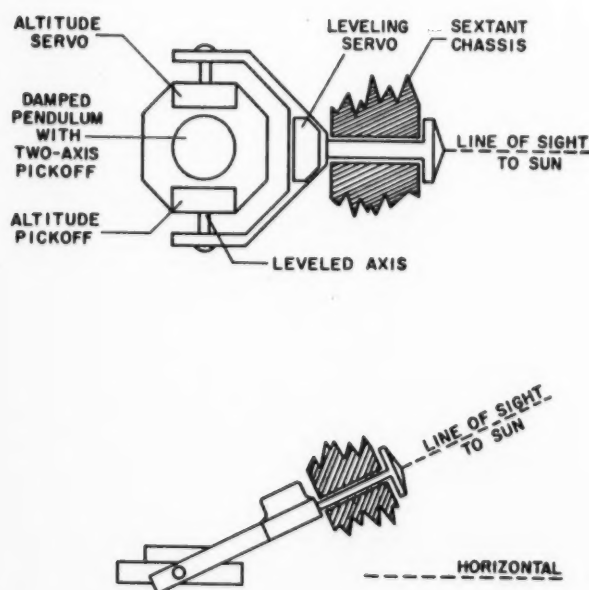


FIG. 7. ELEVATION SENSOR.

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Controls and Readout

Relative bearing information is available at the mounting base from the synchro attached to the first axis. This information together with the altitude signal extracted through separate slip rings from the internally-mounted pendulum, can be displayed remotely on dials located on a small control panel. The relative bearing could be automatically added to compass heading, by means of a simple differential in the control panel, to provide actual azimuth readings. The control panel should also include a klystron-repeller voltage control and crystal-current meter, and a search control and radiometer output meter as well as switches for manually slewing the bearing and elevation to any desired positions. A possible control-panel arrangement is shown in Fig. 8.

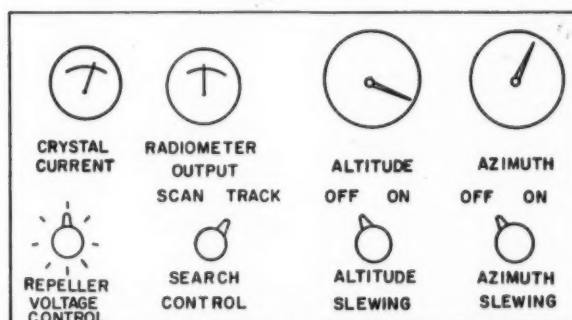


FIG. 8. CONTROL PANEL arrangement.

Advantages

The advantages of the radiometric inertial reference system over other existing trackers are:

1. The system is compact and self-contained. No auxiliary equipment is needed.
2. No elaborate computer is needed to compensate for earth rotation or base motion.
3. The tracking function is independent of any vertical reference.
4. The mount accommodates pitch & roll motions up to 90°.
5. The mount is statically balanced and nearly free of asymmetric wind loading.
6. No precision machining of gimbal rings and bearings is required.
7. System is designed for primary accuracy in altitude and secondary accuracy in azimuth for compatibility with navigation needs.
8. Using a 24" antenna stabilized with 3°/hr gyros, the device can track the sun within 20 seconds of arc with a 6-second time constant, and the moon within 3 minutes of arc with a 60 second time constant.

For more information on Radiometric Inertial Reference circle 211 on inquiry card.

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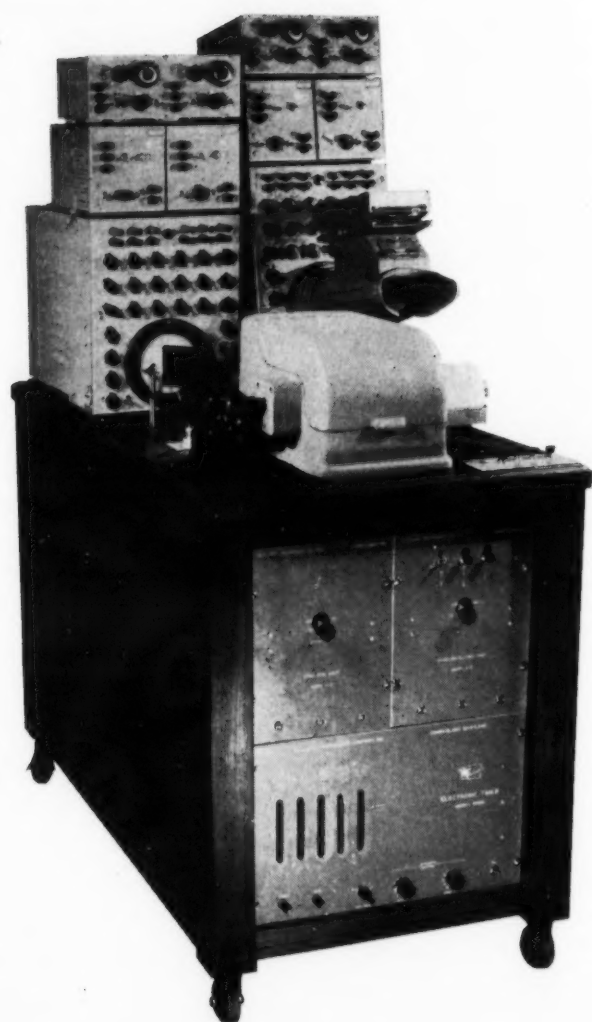


FIG. 1. DYNAMIC TEMPERATURE and strain recorder ALINCO Model 204 includes all necessary amplifiers and balancing equipment, automatic calibrators, dual-beam cathode-ray oscillograph, electronic timer, control units, drum drive units, and circuitry for automatic sequencing of calibration steps and event initiation to record photographically four channels of data plus marks. A Land Polaroid camera is shown on one scope. (Other models up to 12 channels.) Stress analysis made by Hesse-Eastern of Cambridge, Mass., of the dynamic loading of one type of rocket motor resulted in a 12% reduction in its weight. (Photo courtesy Allegany Instrument Co.)

FIG. 3. SCOPE DISPLAY PHOTOGRAPHED by Model 204 recorder shows pressure calibration markers and 1-millisecond timing marks recorded on film prior to firing. Sweep is set for estimated duration of firing. The firing impulse triggers the sweep and 1/10-millisecond pulses are applied to intensity modulate the trace. Projectile (30 mm) exit time and pressure are indicated as an amplitude marker on the time-pressure curve. (Photo courtesy Aircraft Armaments, Inc.)

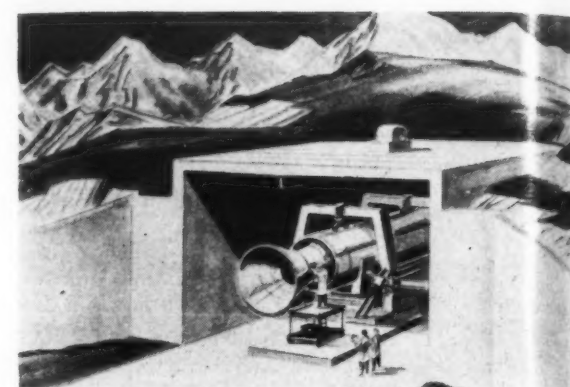


FIG. 2. THIOKOL'S RECENTLY completed Utah Division has facilities to test rocket motors up to 12' diameter. (Drawing courtesy Thiokol Chemical Corp.)

Internal Ballistics Testing

SOLID PROPELLANTS for projectiles, rockets and missiles involve continual and voluminous testing. The best measure of gunpowder or rocket propellant is in its carefully documented test-firing behavior. As any artillery sergeant or gunner's mate can tell you, this behavior pattern is not stable; it is affected by age and by storage conditions such as temperature and humidity. Magazine records and current ordnance instructions determine whether a particular stock of ammunition is held for ready service, expended for practice, or returned to the nearest arsenal for testing and "reconditioning."

Testing is necessary also in the production quality control of solid rocket propellants and assumes particular importance during the development of new propellants and rockets, which must have thrust char-

acteristics hand tailored to fit each missile application.

Testing of solid rocket propellants involves the study of the thrusts, pressures and temperatures produced by various formulations, grain sizes and shapes, and various configurations of propellant charge and discharge vent. Projectile propellants must be designed also to develop an optimum thrust, pressure and temperature pattern during the brief period that the projectile is moving within the gun barrel.

A typical cathode-ray oscillograph record of the pressure vs. time history of a rocket propellant is shown in Fig. 6. Several ballistic laboratory setups featuring testing equipment specifically designed for solid-propellant testing are shown in the accompanying illustrations.

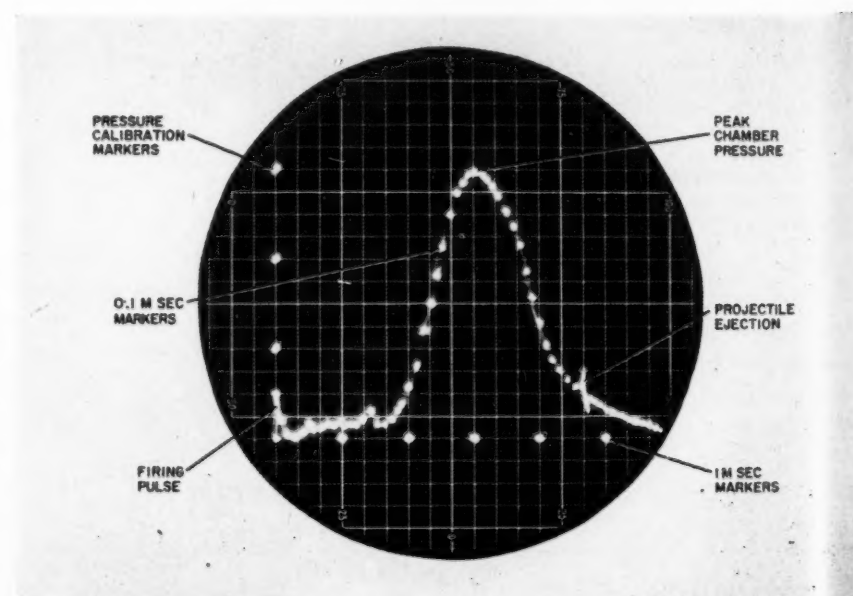




FIG. 4. DYNAMIC RECORDERS and K-1 ballistic computer are wall mounted at the Thiokol Chemical Corporation laboratory. The 2" T-215 air-to-air rocket, the 2" T-216 practice rocket, the M-58 propulsion unit for the Falcon missile, the M7A1 spin rocket for the Honest John and the T-2007 anti-aircraft rocket all have been evaluated here. (U. S. Army photograph)

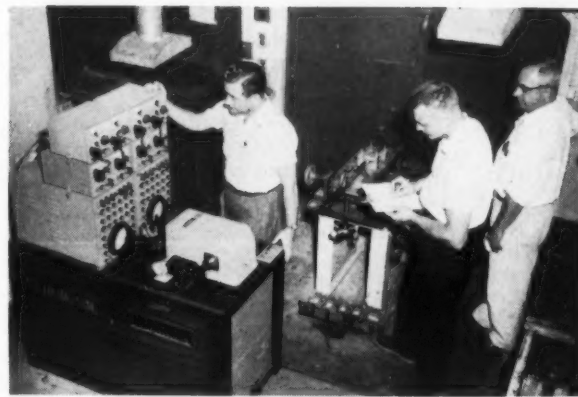
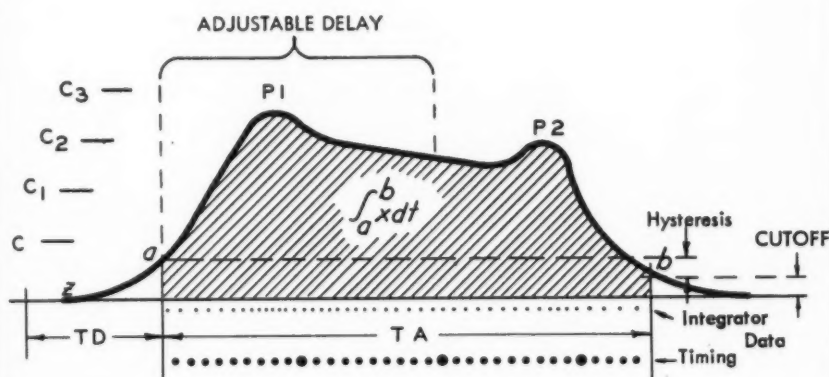


FIG. 5. INSTRUMENTATION FOR 30-MM AMMUNITION testing includes preamplifiers, sweep initiator, muzzle-break pulse generator (pulse is derived from rupture of a wire stretched across muzzle end of gun), piezoelectric crystal gage, voltage calibrator, firing test stand, and dynamic recorder. (Photo courtesy Aircraft Armaments, Inc.)



$\int_0^b x dt$	Area of shaded portion
TD	Time from z to a (Ignition Delay)
TA	Time from z to b (Action Time)
P1	Initial signal peak
P2	Final signal peak
Delay	Time gate which allows P1 or P2 to be recorded as selected on Peak Digitizer.
Cutoff	Control on Time Standard to set "turn on" and cutoff level of points a and b. Adjustable from zero to full scale.
Hysteresis	Control on Time Standard to set differential signal level between points a and b.
C, C1, C2, C3	Automatic Calibration

FIG. 6. CATHODE-RAY OSCILLOGRAPH RECORD shows the pressure-vs.-time history of a rocket propellant. (Drawing courtesy Allegany Instrument Co.)

FIG. 7. TYPE K-1 BALLISTIC COMPUTER converts two channels of analog data to digital form, computes such parameters as ignition delay, action time, integrals of thrust and pressure, peak values of thrust and pressure, etc., while giving visual displays of each parameter and providing printout to Clary printer (paper tape) or IBM summary card punch. This computer has been used in testing rocket engines such as the XM-10 Lacrosse, the XM-22 Hawk and the XM-30 sustainer unit for the Nike-Hercules missile. (Photo courtesy Allegany Instrument Co.)

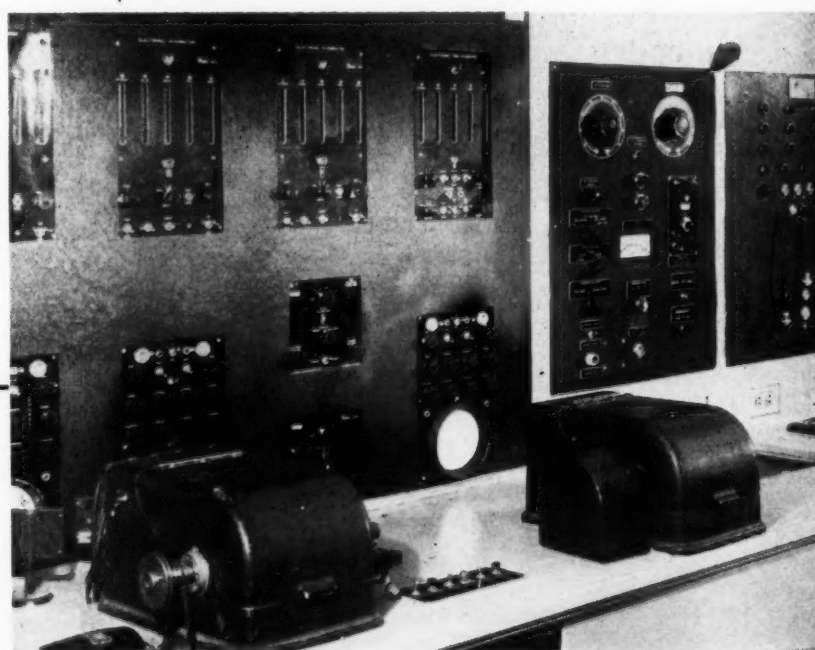


FIG. 8. INSTRUMENTATION AT RADFORD ARSENAL (operated by Hercules Powder Co.) measures burning time in microseconds and records pressures and thrusts developed in testing. Hercules engineers report that the average difference between duplicate independent impulse measurements is less than 0.5%. Each of four firing bays at Radford Arsenal can test rockets delivering up to a million pounds thrust. Allegany Instrument Company supplied the instrumentation. (U.S. Army photograph)

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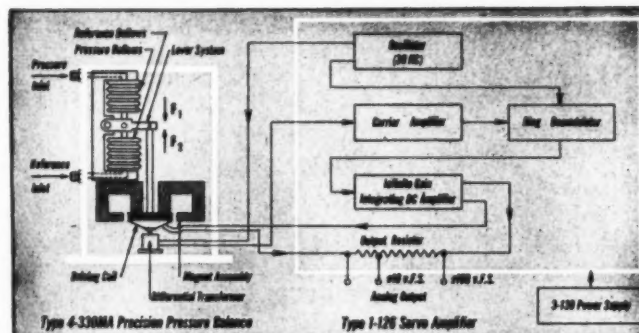
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The characteristics of the high-speed Electromanometer make it applicable where many items are to be tested in as short a time as possible such as production calibration of hundreds of pressure pickups daily. Other uses are on-line monitoring of critical wind-tunnel pressures to determine mach numbers and laboratory calibration of airborne air-data computers. Typical jet aircraft and missile applications include ramjet engine pressure ratio control system calibration, field test of jet engine control systems, preflight calibration of liquid rocket fuel oxidant utilization systems.

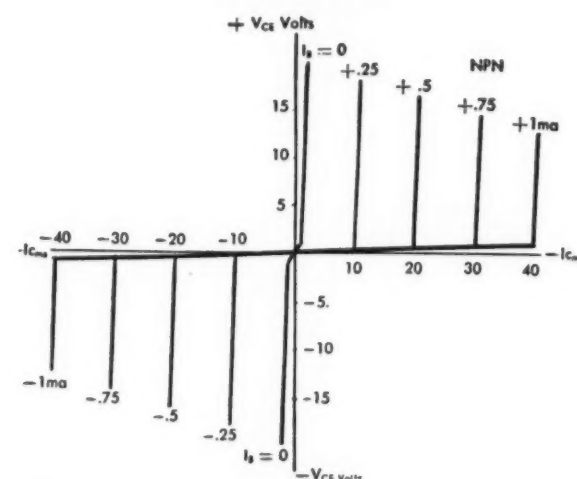
When pressure is applied to the bellows inside the pressure balance, a mechanical force is developed, causing movement of the frictionless linkage system. This minute movement is sensed by the differential transformer. Voltage from the differential transformer is then amplified and fed to a ring demodulator which provides a signal for the infinite-gain integrating d-c amplifier. The d-c amplifier produces current in the driving coil of the pressure balance. The resulting electromagnetic force from this coil opposes the original pressure force, causing a movement of the linkage back to zero position. The two forces are in equilibrium at null balance and analog output voltages are developed directly proportional to the input pressure and unbalance force.

Response time of CEC's high-speed Electromanometer is 0.1 second and resolution is 0.001% of full scale. Output is in tens of volts rather than in millivolts, eliminating the need for intermediate amplifiers. Pressure balances can be located up to several hundred feet from the servo-amplifier system. The high-speed electromanometer is comprised of three basic units:

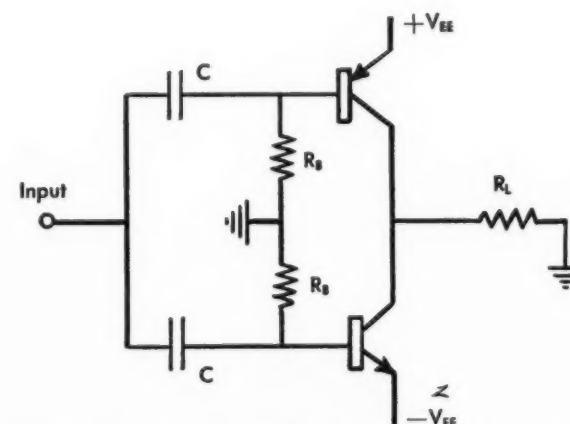
a Type 4-330MA high speed pressure balance, a Type 1-126 single-channel servo amplifier, and a Type 3-120 power supply. A multi-channel adapter is available as optional equipment. It permits using up to six different pressure balance assemblies with a single 1-126 servo amplifier. The unit contains all necessary calibrating, balancing, and zeroing controls. (From new 2-page Bulletin 1586, Consolidated Electrodynamics Corp., 300 N. Sierra Madre Villa, Pasadena, Calif.)

For this literature circle 103 on inquiry card.

Complementary Symmetry Transistors



Typical static output characteristic of complementary symmetry pair.



Typical class A push-pull output stage. The circuit shown will provide twice the voltage gain and twice the maximum output power of a single transistor with a reduction in even-order harmonic distortion.

The GT-SMP series are matched pairs of NPN & PNP transistors recommended for use in complementary symmetry applications such as transformerless class B push-pull output stages, d-c coupled amplifiers, and balanced modulators. (From new 2-page bulletin, General Transistor Corp., 91-27 138th Place, Jamaica 35, N. Y.)

For this literature circle 104 on inquiry card.

MA

New Products

TWO-WIRE THERMAL SWITCH

New hermetically-sealed two-wire thermal switch for use in pipes, bearings, etc., uses a bimetal element



and stainless steel body. Range from -65°F to $+700^{\circ}\text{F}$. Load rating 2 amp resistive at 28 vdc or 115 vac.—*Control Products, Inc.*, 306 Sussex St., Harrison, N. J.

For more information circle 301 on inquiry card.

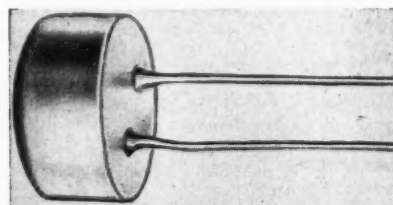
LOW-COST VOLTAGE REGULATOR

New voltage regulator with no moving parts is a single-stage magnetic amplifier unit using selenium rectifiers and wire-wound resistors. Working into a 20 to 100 ohm exciter field resistance without adjustment, it supplies exciter field current within a range of 0.15 to 1.35 ampere. It connects directly into any 208 to 240 v alternator without using potential transformer.—*Vickers Electric Div.*, *Vickers Inc.*, 1815 Locust St., St. Louis 3, Mo.

For more information circle 302 on inquiry card.

SUBMIN TOROIDS

New series of printed-circuit subminiature toroids for use with automatic production techniques have inductance values up to 4 Hy. Toroids



are round case type, .675" OD, with Q values of 45 at 5 kc, 165 at 5 mc, and test-proved to meet government specifications. Transistor transformers are also available in same package.—*Torotol, Inc.*, 11505 Belmont, Hickman Mills, Mo.

For more information circle 303 on inquiry card.

PULSE AMPLIFIER

New Model 672A linear amplifier, built to ORNL Spec. Q13226, amplifies pulses of low signal level from radia-

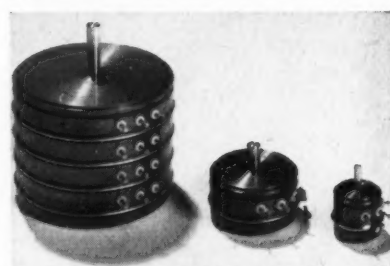


tion detectors such as ionization chambers, proportional counters and scintillation counters to usable levels for scalars, ratemeters and pulse height analyzers. Has input sensitivity from 200 μv to 1 mv; gain is 12,000 to 2000 depending on bandwidth switch position.—*The Victoreen Instrument Co.*, 5806 Hough Ave., Cleveland 3, Ohio.

For more information circle 304 on inquiry card.

PRECISION POTENTIOMETERS

New "1000 Series" potentiometers are first components to be marketed separately from maker's airborne

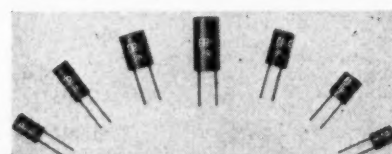


electronic and optical equipment heretofore produced exclusively for the government. The "1000 Series" is made in six sizes, of which three are shown: 1000-F-4 is largest (3" dia.), 1000-D (1 1/4"), and smallest 1000-A (7/8")—*Chicago Aerial Industries, Inc.*, 1980 Hawthorne Ave., Melrose Park, Ill.

For more information circle 305 on inquiry card.

FLAT-TOP RESISTORS

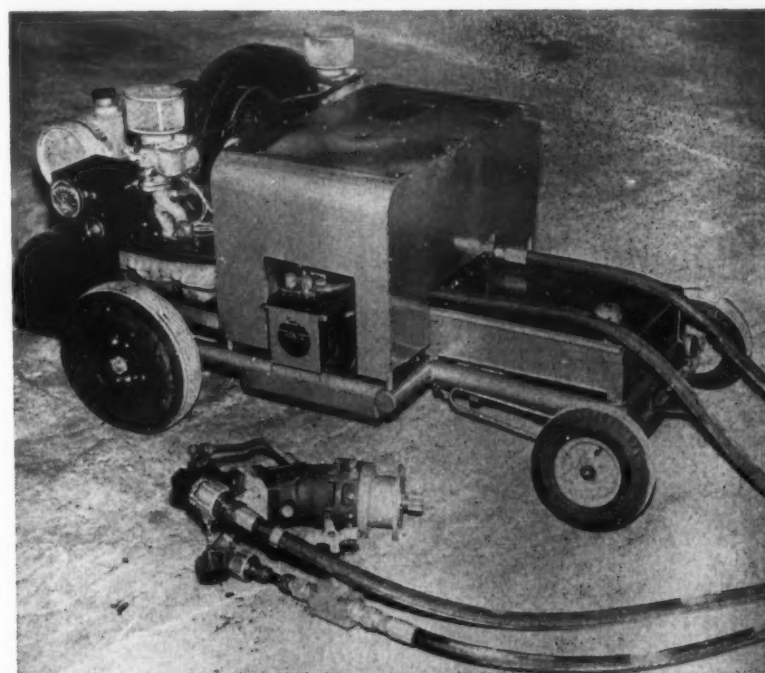
New Type P flat top, encapsulated wire-wound precision resistor, designed for rapid mounting on printed-circuit panels, is a single ended,



miniature series available in 7 sizes—from 1/4" to 3/4" long, resistance to 3 megohms; ratings from 0.1 to 0.4 watt; tolerances from 1% to 0.02%. Type P resistors will withstand all applicable tests of MIL-R-93A, Amdt. 4.—*Resistance Products Co.*, 914 South 13th St., Harrisburg, Penna.

For more information circle 306 on inquiry card.

JET ENGINE STARTER



New portable hydraulic ground-mobile jet engine starter uses a high efficiency Vickers EDV pump driven by a light-weight air-cooled gasoline engine. Servo controls provide correct torque and speed for optimum power utilization throughout entire starting

cycle. Constant displacement piston motor, mounted on engine pad to start the turbine, can be used also as a pump to provide airborne hydraulic power. Prime mover engines from 50 to 250 hp are available.—*Vickers Inc.*, 1400 Oakman Blvd., Detroit 32, Mich.

For more information circle 307 on inquiry card.

AIRCRAFT VALVE/ACTUATOR

New Vapor Electro/Pneumatic valve actuator assemblies, operating from 300 lb. duct pressures, are used to control the amount of hot air mixed with cold air for air-conditioning military jet planes and transports.



Two basic types of assemblies are (1) the ON/OFF type, and (2) the full-modulating variable opening type, which operates in conjunction with a magnetic amplifier control. These assemblies are actuated by electrical signals from various types of temperature controls, such as a resistance pick-up type or a mercury contact thermostat, and have the speed of electrical response, coupled with the power and light weight of compressed-air controls. They meet latest military specifications.—*Vapor Heating Corp.*, 80 East Jackson Blvd., Chicago 4, Ill.

For more information circle 308 on inquiry card.

TELEMETRY UNITS

New REL-09 RF Power Amplifier for airborne telemetering systems is available in 17 configurations by varying connectors, filament voltage and cathode bias; 4.95" x 3.7" x 2"



in size, it weighs just 16 ounces. Two other new items having available 28 configurations are the REL-16 Power Supply Unit, coupled to the REL-11 Voltage Regulator. The Airborne Power Supply REL-16, weighing but 3 pounds 12 ounces, is designed for use when a compact, rugged and completely reliable power supply is essential. The REL-11, in two cases, weighs only 14 ounces.—*Rheem Electronics Div. of Rheem Mfg Co.*, Downey, Calif.

For more information circle 309 on inquiry card.

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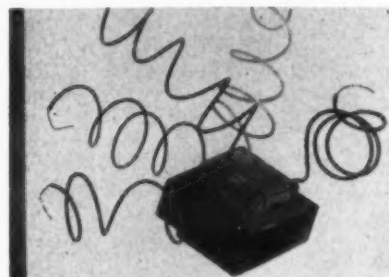
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New Products—Cont.

SODIUM-TREATED LEAD WIRE

New Teflon-insulated flexible lead wire has its surface treated to provide adequate adhesion with impreg-



nated and casting materials. (Heretofore, lack of adhesion caused serious moisture paths, which greatly degraded hermetic seal.) Has same thermal and electrical characteristics as conventional Teflon insulated conductors. All standard color codings.—*Hitemp Wires, Inc.*, 1200 Shames Drive., Westbury, Long Island, N. Y.

For more information circle 310 on inquiry card.

ARC RESISTANCE TESTER

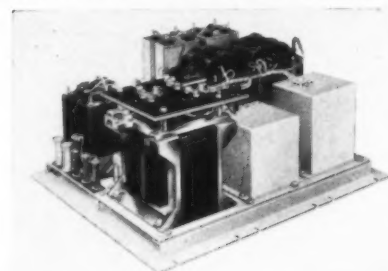
New Model ART-2 meets ASTM Spec D-495-56T and Federal Spec LP-406, Method 4011.2 for measurement of insulation high-voltage arc resistance time; yields readings in five figures to 0.1 sec; has calibrating electrostatic voltmeters and a milliammeter with automatic switching to proper range; has safety interlocks and can be operated by unskilled personnel.—*Industrial Instruments, Inc.*, 89 Commerce Road, Cedar Grove, N. J.

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MAGNETIC V-R

New STABILINE Type TM7105 Automatic Magnetic Voltage Regulator provides maintenance-free regula-

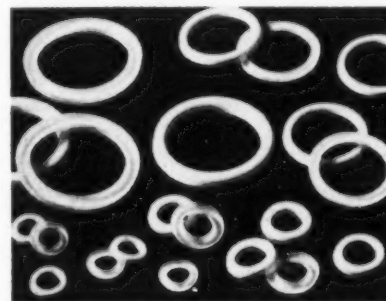


tion despite line voltage or line changes. Using no tubes, transistors or moving parts, it is designed for applications where emergency replacement is costly or impossible. Input—95-135 volts ac; output—adjustable from 110 to 120 volts.—*The Superior Electric Co.*, Dept. TM, 83 Laurel St., Bristol, Conn.

For more information circle 312 on inquiry card.

CHEVRON SEALS

New molded dynamic and static chevron seals feature high flexibility and dimensional stability of Fluorlas-

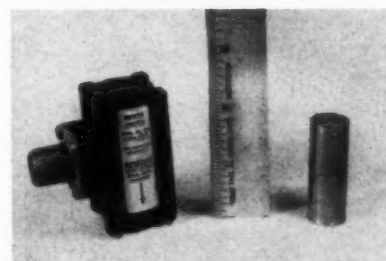


tic Teflon, which maintains size and leakproof characteristics from -350°F to 500°F and from 0 to 1000 psig. New seals resist all chemicals, fuels, solvents and hydraulic oils; can be installed in both rotational and longitudinal movements as well as static positions.—*Joelin Mfg. Co.*, Wallingford, Conn.

For more information circle 313 on inquiry card.

MINIATURE INERTIA SWITCH

New miniature inertia switch said to be the smallest known, uses only one moving frictionless part which



momentarily closes electrical contacts if accelerated above a preset value, (adjustable from 1.5 G up, tolerance

± .15). Volume is ½ cubic inch; weight ¾ ounces. Uses are for aircraft, missiles, electronics, automation, etc. Model 510 is an installation-ready assembly; model 410 is inertia cartridge alone.—*Safe Lighting, Inc.*, 527 Lexington Ave., New York 17, N. Y.

For more information circle 314 on inquiry card.

TEST JIG FOR MAGNETIC CORES

New test jig for precision testing of magnetic-tape-wound bobbin cores applies driving current pulses to core being tested and permits direct view-

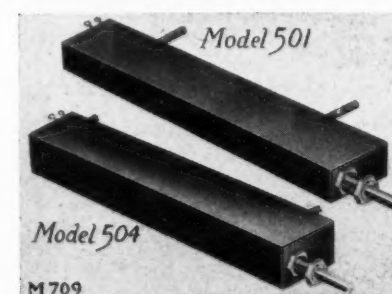


ing (on an oscilloscope) of input pulse and output pulse induced by switching of core. Available in two models (Types 8040 and 8041), difference being size of bobbin flange. Core Tester BCT 301 is a complete system for individually testing tape wound cores.—*Electronic Instruments Div., Burroughs Corp.*, 1209 Vine St., Philadelphia 7, Penna.

For more information circle 315 on inquiry card.

VARIABLE DELAY LINES

Two new continuously-variable delay lines are designed for use as components or as test equipment in ad-

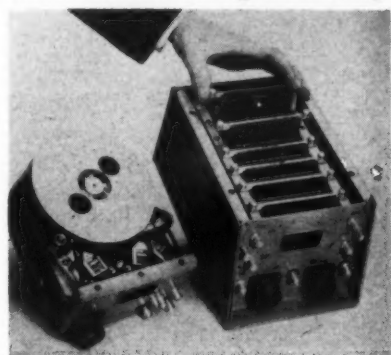


vanced computer and radar systems. Entire delay range, from zero to maximum delay, is covered by a single control shaft, in ten turns, which can be locked at any desired delay by a locking device or left variable. Model 501 features maximum delay of 0.9 usec; maximum rise time of 0.18 usec; impedance of 1000 ohms. Model 504: maximum delay of 9 usec; maximum rise time of 1.7 usec; impedance of 100 ohms.—*ESC Corp.*, 534 Bergen Blvd., Palisades Park, N. J.

For more information circle 316 on inquiry card.

MISSILE DATA RECORDER

New missile mounted Model 600 miniature record-playback system for data acquisition during missile-flight

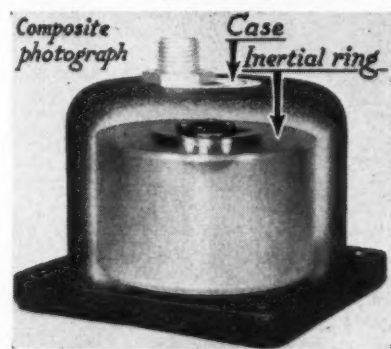


automatically records two tracks of IRIG FM/FM subcarrier signals from 200 to 100,000 cps at 60 ips for a period ranging up to 250 seconds.—*Minneapolis-Honeywell, Davis Division, 10721 Hanna St., Beltsville, Md.*

For more information circle 317 on inquiry card.

ANGULAR ACCELEROMETER

New inertial unit designed for either instrumentation or control systems has completely symmetrical in-



ertial ring. Available ranges from zero to $\pm \frac{1}{2}$ rad/sec², to zero to 100 rad/sec²; resistive or inductive pick-off except in lowest ranges.—*Humphrey Inc., 2805 Canon St., San Diego 6, Calif.*

For more information circle 318 on inquiry card.

DC POWER SUPPLY

New Model "EFB" dual-range dc power supply, designed for transistor circuitry is claimed to have less than 10 millivolts ripple at top load. Supplies a continuously variable power

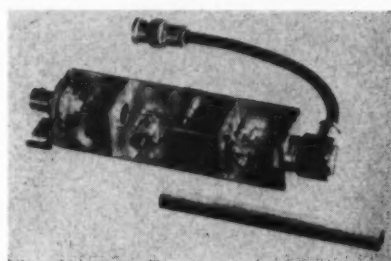


source from 0 to 16 volts for current loads to 8 amperes, and 0 to 32 volts for current loads to 4 amperes. Accurate current and voltages are indicated on D'Arsonval-type meters.—*Electro Products Laboratories, 4500 N. Ravenswood Ave., Chicago 40, Ill.*

For more information circle 319 on inquiry card.

LOW-PASS FILTER

New 400-mc low-pass filter uses maker's new air-dielectric trimmer capacitors to achieve maximum in-

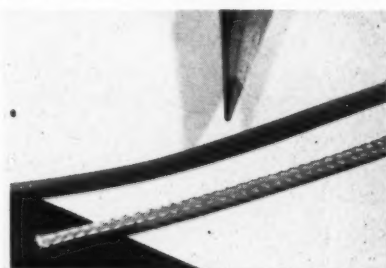


sertion loss from 200 to 400 mc of only 0.75 db with rapid attenuation above the passband, in a volume 1" x 1" x 4". Maximum power handling capacity of the filter is 100 watts; pass-band SWR is 1.5:1; input and output impedance are both 50 ohms.—*Radio Condenser Co., Davis & Copewood St., Camden 3, N. J.*

For more information circle 320 on inquiry card.

HOOK UP WIRE

A new thin-wall synthinol covered hook-up wire does not require an overbraid or thick jacket . . . offers ad-



vantages of less initial cost, less contact resistance when penetrating terminals are used, a minimum effect of humidity changes, elimination of wire breakage, less interwire capacitance, easier and more effective inspection, and greater conductivity for the same overall O.D. wire.—*Rome Cable Corp., Rome, N. Y.*

For more information circle 321 on inquiry card.

SAMPLING SWITCH

New Series 300 high-speed sampling switch has hermetically-sealed case for high-altitude military and commercial applications; up to 2 poles

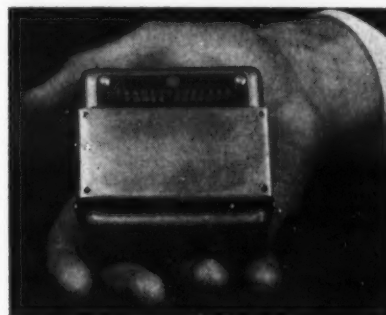


with 30 non-shorting channels per pole. Drive is by 28-vdc motor with governor, arc suppressor and RF filter; or a 115-v single-phase 400-cps hysteresis synchronous motor.—*General Devices, Inc., P. O. Box 253, Princeton, N. J.*

For more information circle 322 on inquiry card.

MOBILE SUPPLY

New transistorized power supply provides greater reliability for two-way radios by replacing receiver

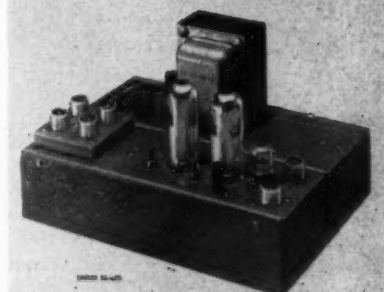
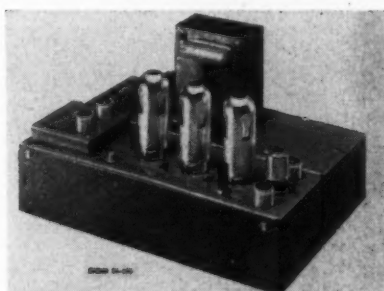


portion of mobile power supply. Is marketed by GE as optional equipment for Progress Line 12 vdc receivers and can also be used with any standard make of mobile equipment using a 12-v power source in 25-54 mc, 144-174 mc and 450-470 mc bands.—*General Electric Co., Communication Products Dept., Syracuse, N. Y.*

For more information circle 323 on inquiry card.

VIDEO AMPLIFIER

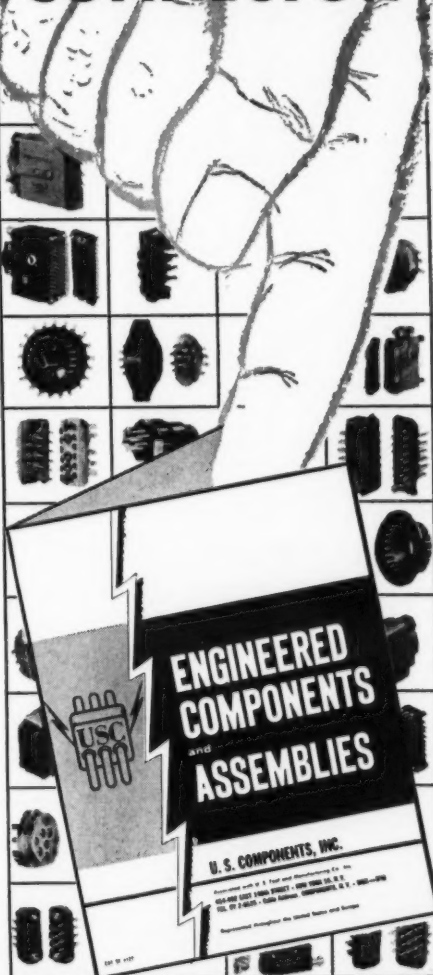
New VHF TV bridging amplifiers now available include unity-gain, four-output Model BA-4; 10-db



gain four-output Model BA-400, and 25-db gain two-output Model B-250. All are for 75-ohm systems and a maximum output of 0.2 volt per channel is claimed. Amplifiers feature single control, adjustable equalization, adjustable gain, plug-in attenuators and silicon power rectifiers.—*Entron, Inc., P. O. Box 287, Bladensburg, Md.*

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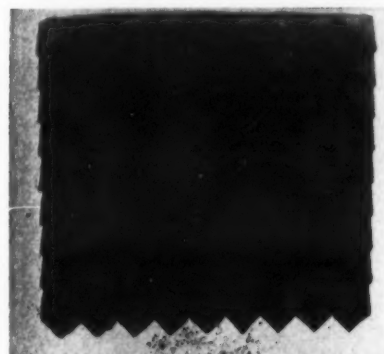
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For more information circle 21 on inquiry card.

New Products—Cont.

MICROWAVE ABSORBERS

New Glennite microwave absorbing materials for use where radiating microwave equipment must be aligned

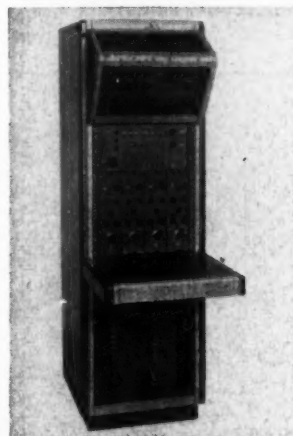


or tested in restricted spaces is made in two classes: one is wide-band, the other utilizes interference principle. Both feature low reflectivity and high absorption at CM wavelength and elimination of unwanted permanent echoes.—*Gulton Industries, Inc.*, 212 Durham Ave., Metuchen, N. J.

For more information circle 325 on inquiry card.

PROGRAMMED PULSE GENERATOR

New Model 1020 Programmed Current Pulse Generator provides precisely controlled, fully programmed



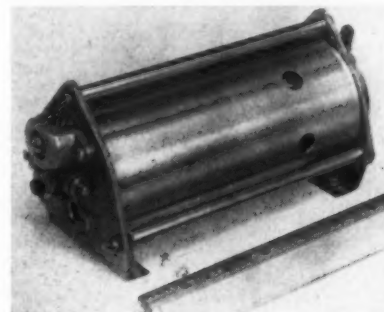
current pulses for research, development and production testing of digital systems and components. Its stable, high-level current pulses, generated from a high source impedance, are said to be especially effective in analyzing highly inductive magnetic elements or for driving magnetic-core logic systems.—*Rese Engineering, Inc.*, 371 Arch St., Philadelphia 6, Pa.

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TUNABLE STALO

New stable L-Brand local oscillator, tunable over a 10% frequency range, has power output of 500 milliwatts or

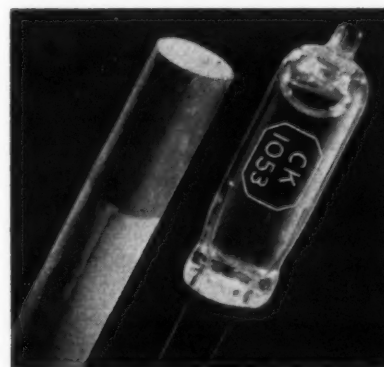


greater with stability of 4-8 cps peak (short-term deviation). Added AFC, frequency range modifications and multiple outputs, etc., may be provided to meet customer requirements.—*Pitometer Log Corp.*, 237 Lafayette St., New York 12, N. Y.

For more information circle 327 on inquiry card.

OPERATING TIME INDICATOR

Novel subminiature tube Type CK-1053 is said to measure operating time up to 5000 hours with accuracy



of 5% or better, in situations where the total on-time of equipment is desired. Operating current is passed through the tube whenever the equipment is in use. Inexpensive colorimeters indicate elapsed time.—*Raytheon Mfg. Co.*, 55 Chapel St., Newton 58, Mass.

For more information circle 328 on inquiry card.

ENCAPSULATED MINIATURIZED ROTARY SELECTOR SWITCH

New Series BHM "POTPOT" encapsulated switch is designed for multiple switching applications where components must meet salt spray, humidity and temperature cycling requirements. Rated for 50 ma at 300



vac/dc and 500 ma at 30 vac/dc. Available with color-coded leads in S.P. 12 positions, 2 P. 6 positions, 3 P. 4 positions, 4P. 3 positions, and either shorting or non-shorting contacts.—*Clarostat Mfg. Co., Inc.*, Dover, N. H.

For more information circle 329 on inquiry card.

HEAT-DISSIPATING SHIELDS

New NW type shield (NW6-6528) was designed especially for tubes with dimensions of Bendix 6094; will

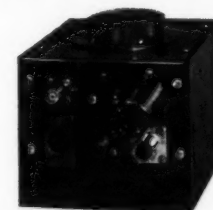


lower the bare-bulb temperature of a 6094 operating at 16 watts dissipation by more than 60° C; is available to fit all standard sizes of 7- and 9-pin miniature tubes.—*International Electronic Research Corp.*, 145 W. Magnolia Blvd., Burbank, Calif.

For more information circle 330 on inquiry card.

PHOTOMULTIPLIER PREAMPLIFIER

New N-352 Photomultiplier Pre-amplifier for scintillation spectroscopy has pre-wired photomultiplier socket and cathode follower with 70-ohm output impedance mounted in a

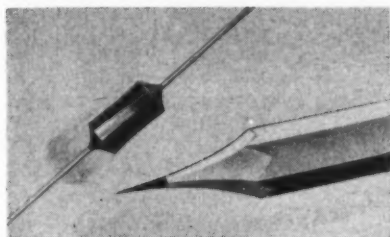


counter-weighted aluminum box. Pre-amplifier is particularly suitable for driving long coaxial cable having a Z₀ between 65 and 78 ohms, but can be modified to match 51-ohm cable.—*Hamner Electronics Co., Inc.*, P. O. Box 531, Princeton, N. J.

For more information circle 331 on inquiry card.

SUBMINIATURE RESISTOR

New type 1274 wire-wound encapsulated micro-miniaturized is rated



at 0.25 watt; maximum resistance 250,000 ohms; meets all requirements of MIL-R-93-A, except physical size.—*The Daven Co., Livingston, N. J.*

For more information circle 332 on inquiry card.

VIBRATOR REPLACEMENT

New low-cost transistorized replacement for vibrators in two-way mobile radio communications equipment is claimed unique in its capacity to



operate both transmitter and receiver units. Designed for 12-v systems, it can switch 9 amps dc; operates on either positive or negative sources. Transistorized circuit reduces interruption of service due to vibrator failure in radio-controlled vehicles such as cabs, government and military vehicles, aircraft, etc.—*Transval Engineering Corp., 10401 Jefferson Blvd., Culver City, Calif.*

For more information circle 333 on inquiry card.

SYNCLAMPS

New "SYNCLAMPS" provide a standard component clamp meeting governmental shock, vibration and

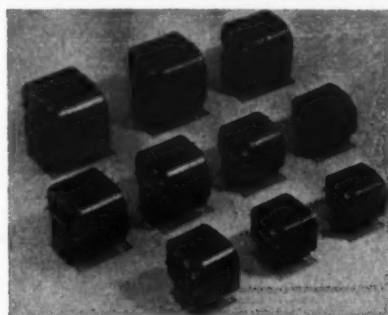


environmental tests. Is said to be the only quick-release synchro clamp.—*Timber-Top, Inc., P. O. Box 14, Freeport, N. Y.*

For more information circle 334 on inquiry card.

MOLDED TRANSFORMERS

New series of standardized molded transformers for airborne applications is now available in standardized

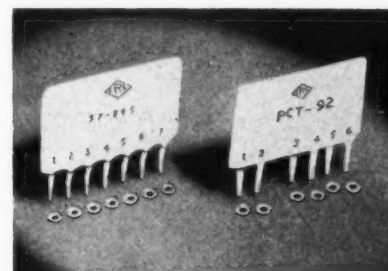


sizes for units from .2 lbs. to 1.5 lbs. Dimensions range from type M1, 1-3/4 x 1-3/8 x 1-5/8 x 2"; to type M10, 2-1/8 x 2 7/8 x 3". Units meet MIL-T-27A grade 2 and Grade 5 tests for both standard and high temperature applications.—*The United Transformer Corporation, 150 Varick St., New York 13, N. Y.*

For more information circle 335 on inquiry card.

PACKAGE CIRCUITS

New narrow-tab-terminal P.E.C. (packaged electronic circuit), for use with printed or etched-board circuitry,



was designed for automatic insertion but can also be manually inserted. New narrow tab terminals plug in to 0.055" holes with perfect alignment of terminals on 0.172" centers.—*Centralab, Division of Globe-Union Inc., 900 E. Keefe Ave., Milwaukee, Wis.*

For more information circle 336 on inquiry card.

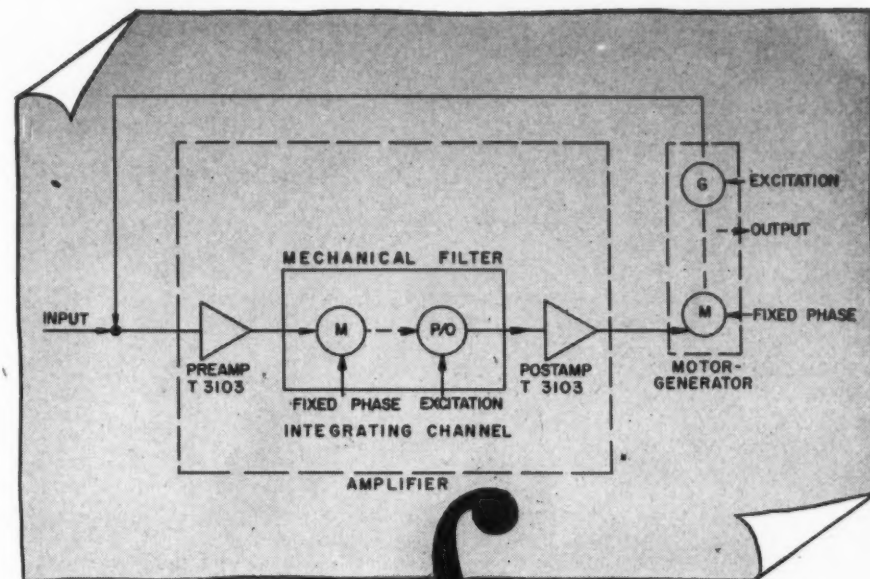
A-D/D-A CONVERTER

New completely transistorized "Multiverter" provides two-way conversions at accuracies better than



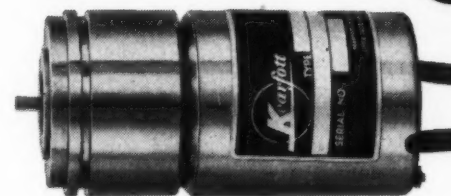
.01% and speeds over 15,000/sec. for analog-to-digital conversion, and 300,000/sec. for digital-to-analog conversion.—*Packard-Bell Computer Corp., 11766 W. Pico Blvd., Los Angeles 64, Calif.*

For more information circle 337 on inquiry card.



This diagram illustrates an optimum configuration of a precise integrating servo system. The essential components are shown below.

$\int (f) dt$



SERVO MOTOR GENERATOR

This size 15 unit represents the latest in design for precise integrating tachometers. Temperature stabilized to within 1° C; linearity, 0-3600 R.P.M., .03% of 3600 R.P.M., 0-4800 R.P.M., .05% of 3600 R.P.M.



MECHANICAL FILTER

This size 11 filter, used in conjunction with amplifiers shown, provides an integral-plus-proportional circuit. Eliminates quadrature and noise in the error signal and the need for high gain, critical amplifiers.



TRANSISTORIZED AMPLIFIERS

This T3103 amplifier provides a 40 v., 6 w. output. Meets the requirements of MIL-E-5400. Dimensions 1 5/8" x 1 5/8" x 1 7/8" high, weight 4.7 oz.

The above units are available as components for your specific applications or as packaged sub-assemblies.

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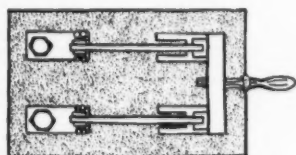
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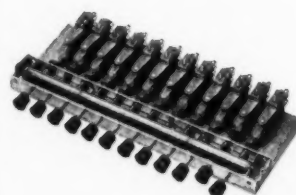
For more information circle 23 on inquiry card.

SWITCHING



Yesterday

Low-current electrical switching problems were solved adequately by a simple knife-type switch controlling only one circuit.



TODAY (and for tomorrow)

Computers, telemetering, modern electronics and communications systems have made constant demands on switch designers for improved, more flexible components. General Control Company has met these demands.

The Multiple Push Button switch shown here is one answer. Designed for use in the industrial, electronic, aviation and guided missile fields, it is compact and rugged. One 12-button switch can control up to 96 circuits. They are supplied with 2 to 12 positions in either 1 or 5 ampere ratings. Rows of 2 or 3 banks can be intercoupled for single-switch action. Flexibility in design of the frame, button action and contact arrangements permits most applications to be met with standard MPB's.

Write for Bulletin PB-300 or see our catalogs in Radio's Master or Sweet's Product Design File.

GENERAL CONTROL COMPANY
 1228 Soldiers Field Road • Boston 34, Massachusetts

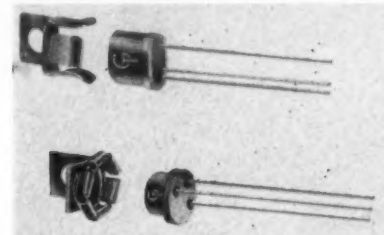
**SWITCHING
TIMING**

For more information circle 24 on inquiry card.

New Products—Continued

HEAT SINKS

New beryllium copper heat sinks enable transistor to operate at higher levels of dissipation and provide a



mounting clamp for transistor where transistor is suspended by its leads and not used with socket. Model HS-10 is designed for GT soldered case; Model HS-20 for GT version of JETEC 30 case.—General Transistor Corp., 91-27 138 Pl., Jamaica 35, N. Y. For more information circle 338 on inquiry card.

"TAN-O-MITE"

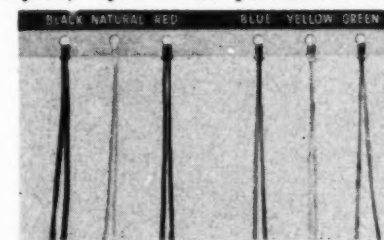
New sub-miniature tantalum capacitors are said to constitute smallest units available. Size "S" is 3/16"



length by 5/64" diameter; size "T" is 5/32" by 5/64" but provides capacities to 4 mfd. Tantalum electrolytic capacitors, noted for high capacity per unit volume, long shelf life and electrical stability, are being increasingly used at low dc voltage in transistorized and miniaturized equipment.—Ohmite Mfg. Co., 3629 Howard St., Skokie, Ill. For more information circle 339 on inquiry card.

COLORED LACING TAPE

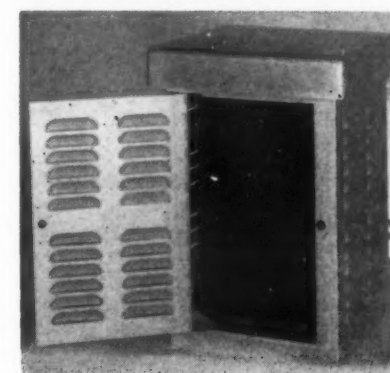
New Gudlace for color-coding of circuits comes in six non-fading colors; is braided of pure DuPont Nylon, dyed with permanent non-



toxic dyes, given a special microcrystalline wax finish and further protected by a special fungicidal agent. It is moisture-resistant, unaffected by temperatures from -67°F to 200°F; soft, pliable and inert.—Gudebrod Bros. Silk Co., Inc., 225 West 34th St., New York, N. Y. For more information circle 340 on inquiry card.

WEATHERPROOF PREAMP

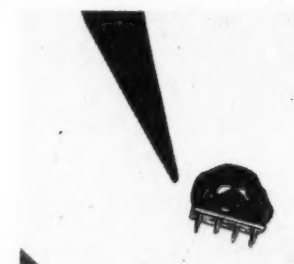
New type PR-200 preamplifier for use with telemetering receivers is weatherproof and pressurized so that



it can be located at antenna to minimize receiving system losses without encountering moisture problems. Pass band has uniform response (3 db) over a frequency range of 215-245 megacycles.—Nems-Clarke, Inc., 919 Jesup-Blair Dr., Silver Springs, Md. For more information circle 341 on inquiry card.

PRINTED-CIRCUIT TRANSFORMER

New high-precision plug-in transformers for latest printed-circuit applications are epoxy encapsulated,



designed for maximum moisture resistance, and insulated for high operating temperatures. Plug-in terminals are spaced for standard 0.1" grids.—Celco Constantine Eng'g Labs Co., Island Ave., Mahwah 1, N. J. For more information circle 342 on inquiry card.

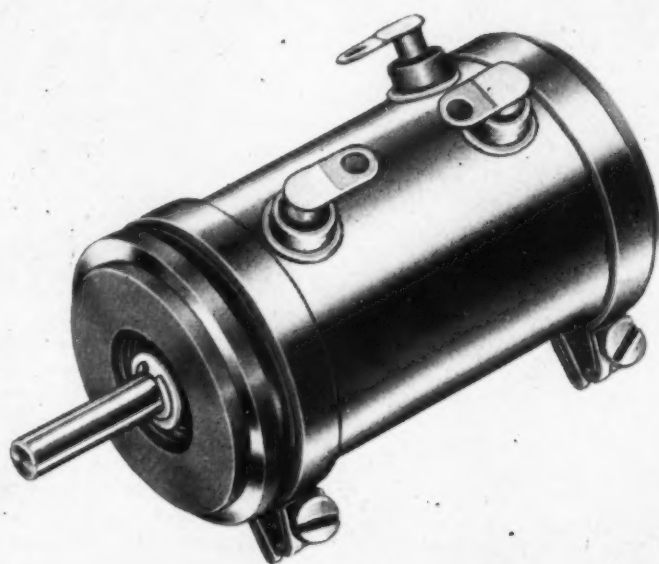
HI-TEMP SYNCHROS

New 450°F temperature-resistant size 10 synchros include a transmitter



for direct turbojet-engine mounting; also transformers, differentials, and resolvers.—Clifton Precision Products Co., Inc., 9014 West Chester Pike, Upper Darby, Pa. For more information circle 343 on inquiry card.

MULTI-TURN POT



New Type 909 $\frac{1}{2}$ "-dia multi-turn pot is first to use a new helical slip-bar wiper guide. Can be manufactured in 3-turn or 20-turn version or any degree of electrical rotation in between. Simplified ganging and easy phasing are other features. Typical

resistance range is 100 to 200,000 ohms for 10-turn version; standard linearity is 0.5% (0.5% on special order).—*Fairchild Controls Corp., Components Div., 225 Park Ave., N. Y.*

For more information circle 344 on inquiry card.

AC ACCELEROMETER

New series 4204 AC output linear accelerometer for high response systems is said to provide an accurate,

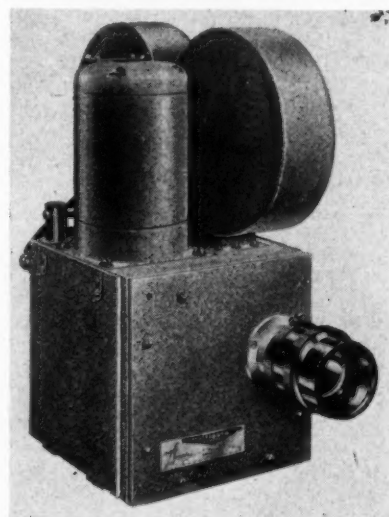


large output signal while maintaining a high natural frequency and low cross-talk. Temperature-compensated fluid damping is constant over operating temperature range without a heater, providing exceptionally good dynamic characteristics.—*Pacific Scientific Co., P. O. Box 22019, Los Angeles, Calif.*

For more information circle 345 on inquiry card.

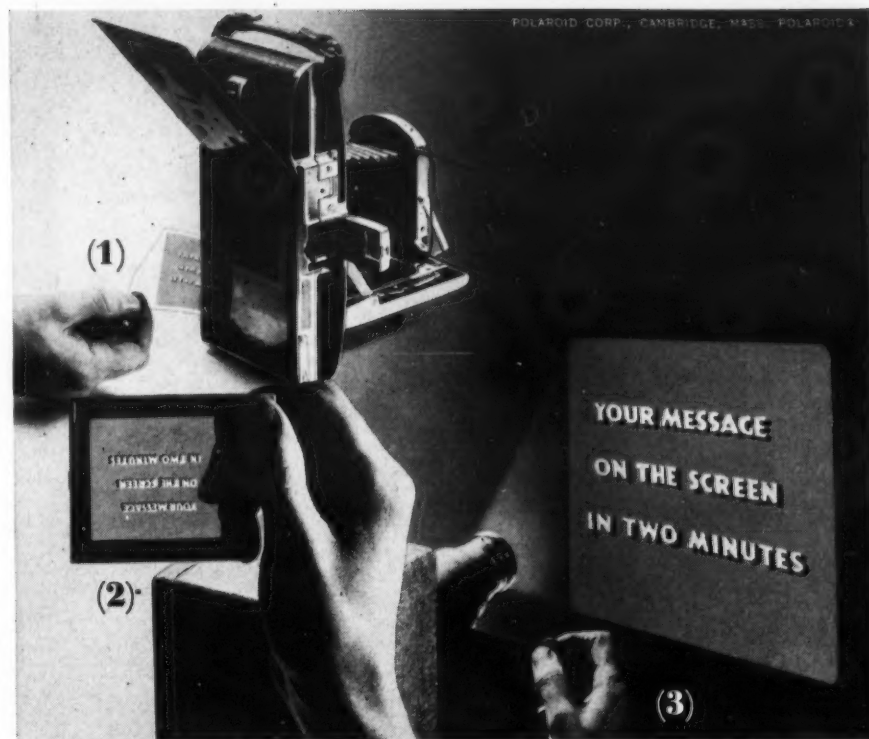
MISSILE TRACKING CAMERA

New 70-mm Multidata Mod V provides a more detailed record of missile flight than 16-mm or 35-mm cameras. With same focal length lenses it mini-



mizes effect of tracking error; also permits using greater focal lengths for greater magnification to record fin flutter, exhaust nozzle characteristics, missile attitude, exhaust patterns, etc. Features: Neon light timing system, four lighted fiducial markers, and automatic center-of-exposure marking pulse.—*Flight Research, Inc., Byrd Airport, Richmond, Va.*

For more information circle 346 on inquiry card.



(1) Snap it... see it! (2) Slip it into a mount, and (3) project it as big as you want.

Polaroid Corporation Announces

QUICK, EASY WAY TO MAKE SLIDES

Polaroid Corporation has perfected a film which produces black-and-white slides right in a regular Polaroid Land Camera. Just click the shutter and two minutes later you have a slide ready for projection. In industry, education, sales, real estate, speechmaking, safety, medicine, law and countless other fields this new system has proved invaluable. **These slides save time and effort**—cost about one-third as much as conventional slides. Send in this coupon for more detailed information.

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CITY _____ STATE _____
ZONE _____

For more information circle 25 on inquiry card.

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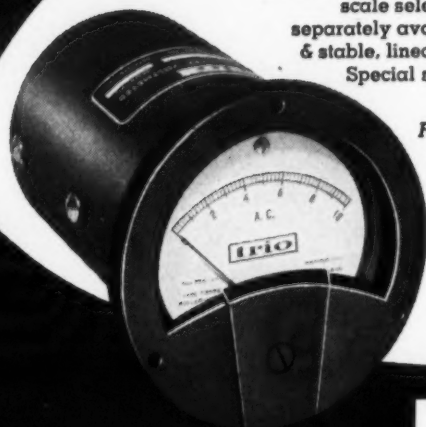
high temperature build-in miniature AC VTVMs

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meter space

for building into equipment meeting MIL-E-5400 and MIL-T-945A; uses meter meeting MIL-M-10304A. Series 121 single-range AC VTVMs withstand as high as 85° C, maintain $\pm 2\%$ full-scale accuracy to as high as 71° C. Input Z 1 meg, frequency range 20-50,000 cps — available in any range from 30 MV to 300 VAC. Power required is 6.3 V and 125-200 VDC (Trio Model CP auxiliary power supply available). Highly flexible automatic scale selection. Adding extra terminals makes separately available both the 200 μ A DC meter & stable, linear, current-feedback amplifier. Special scaleplates, ranges, Z's on request.

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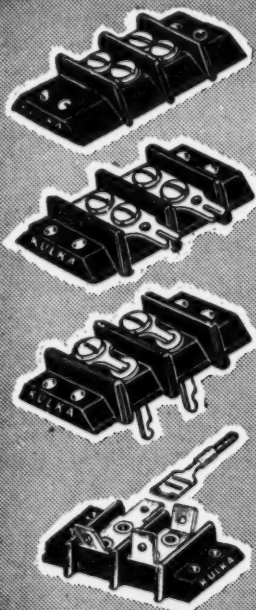
when ordinary instruments are
too big or inadequate

trio

For more information circle 26 on inquiry card.

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Designed For Performance and Economy

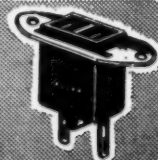
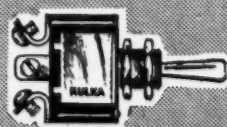


TERMINAL BLOCKS (Left): Large line of molded, barrier type, in varied sizes, materials, and terminals. New "KLIPTITE" style (left bottom) with angled tabs made for AMP, self-locking wire terminals.

TOGGLE SWITCHES (Below): Aircraft type, Single and Double Pole. Bakelite housing. Screw terminals or soldering lugs. One-hole mounting. DC, or AC up to 1600 cycles.

POWER OUTLETS (Below, right): Smallest made for standard plug. Mounts from top or bottom of bracket. Soldering terminals or wire leads.

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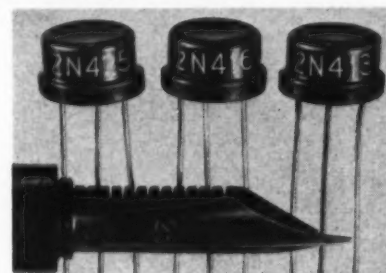
633-643 SO. FULTON AVE. MOUNT VERNON, N. Y.

For more information circle 27 on inquiry card.

New Products—Cont.

PNP TRANSISTORS

New PNP germanium transistors in the JETEC-30 standardized package include types 2N425, 426, 427 and 428

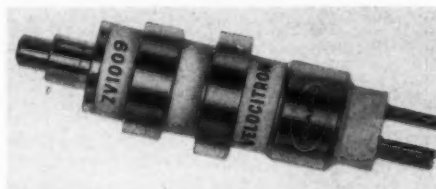


for computer use, with alpha frequency cutoff values of 4 to 17 mc. Types 2N416 and 417 are for special purpose RF applications, with cutoff of 10 and 20 mc. Six other types are for portable radio receiver local oscillators, converters and IF amplifiers. —Raytheon Mfg. Co., 55 Chapel St., Newton 58, Mass.

For more information circle 347 on inquiry card.

CERAMIC KLYSTRON

New ruggedized ceramic klystron tube, Velocitron ZV1009, is a physical and electrical replacement for kly-



stron tubes 6BL6 and 5836 but designed for high temperature, vibration and mechanical shock. Is said to allow for higher ambient temperatures than any glass tube currently available and to be less microphonic and fragile. —Polarad Electronics Corp., 43-20 34th St., Long Island City 1, N. Y.

For more information circle 348 on inquiry card.

COMPRESSION TESTER

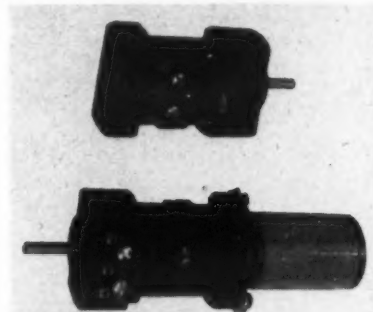


New Model TP-121 portable, hydraulically-operated compression tester combines simple hand-pump operation with ease of adjustment in vertical dimension; has capacity of 150,000 lbs. Many types of work can be accomplished on this simple equipment, thereby freeing Universal Testing Machines for jobs requiring skilled operators and elaborate fixturing. —Steel City Testing Machines, Inc., 8817 Lyndon Ave., Detroit 38, Mich.

For more information circle 349 on inquiry card.

LIMIT STOP ASSEMBLY

New 10-turn miniature Limit Stop Assembly construction insures precise and repeatable adjustment of all



stops. Mechanical stops also can be included to protect the potentiometer (or driven member) if the electrical stop fails. Both mechanical and electrical stop settings can be set to any number of turns—170 or less. Typically used in servo actuators, these assemblies are 1 1/8" long by 1 1/8" diameter flattened to 3/4". —United Hydraulics, Inc., 110 Terrel Ct., Dayton 7, Ohio.

For more information circle 350 on inquiry card.

TEFLON FILM CAPACITORS

New hermetically-sealed Teflon film capacitors, are said to have operating temperature range of -65°C to 165°C without derating,

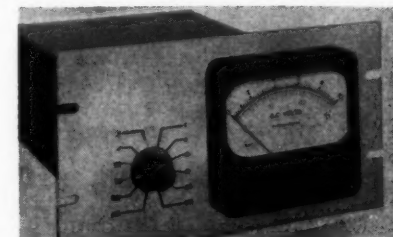


with special models for temperatures up to 200°C with proper derating. Other features: high insulation resistance, low dissipation factor, minimum effect from dielectric absorption, and long service. All Teflon capacitors meet or exceed MIL specifications. —U. S. Electronics Development Corp., 1323 Airway, Glendale 1, Calif.

For more information circle 351 on inquiry card.

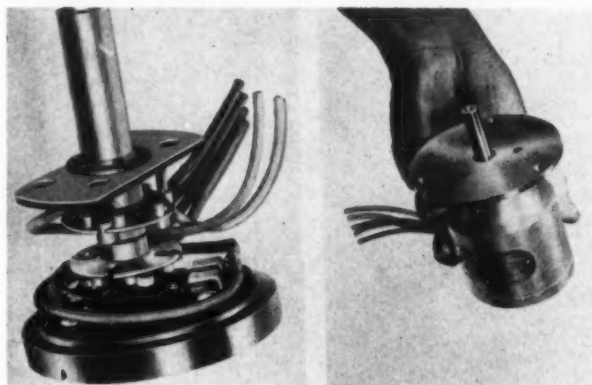
BUILD-IN AC VTVM

New Model 109-1 AC VTVM is designed for integration into test equipment or modular-type consoles.



MILITARY AUTOMATION Septe

SYNCHRO-PAK SPEED DETECTOR



New Synchro-Pak self-contained centrifugal speed detector designed for flange mounting can be coupled by any normal method to the shaft of rotating equipment to detect over-speed and underspeed in a narrow or

wide range. Illustration shows a 2-stage unit incorporating two switches, one limiting overspeed, the other underspeed, to $\pm 1\%$.—*Torq Engineered Products, Inc., 50 W. Monroe St., Bedford, Ohio.*

For more information circle 354 on inquiry card.

This low-level instrument can read as low as 50 microvolts on its 1mv range. Twelve full scale ranges from 1mv to 300vac are provided with an overall accuracy of 2% of full scale. It operates from a 115v, 500 cps source. Its $5\frac{1}{4} \times 9\frac{1}{2}$ " panel, with standard RETMA notches and spacing, fits standard modular-type consoles. Variations can be provided.—*Trio Laboratories, Inc., 4025 Merrick Rd., Seaford, N. Y.*

For more information circle 352 on inquiry card.

INSTRUMENT CAMERA

New Photo-Sonics 4B employs both a rotating prism and a rotating disc shutter, takes 2800 frames per second; is intended primarily for re-

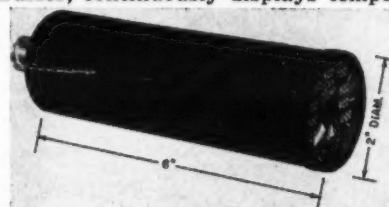


search in missile and related rapid-motion projects. Rotating prism allows continuous flow of film while compensating for image distortion; rotating disc shutter provides exposure control with a high shutter efficiency factor. (Disc shutter interchangeable, with openings of 5° to 60° available.) Film capacity is 500 feet in removable film chamber. Buckle and runout shut-off switches provide automatic protection. Two-light timer and fiducial markers assist data reduction.—*Gordon Enterprises, 5362 N. Cahuenga Blvd., N. Hollywood, Calif.*

For more information circle 353 on inquiry card.

TRANSISTORIZED PYROMETER

New Engine exhaust temperature indicator, originally developed for BuAer, continuously displays temper-

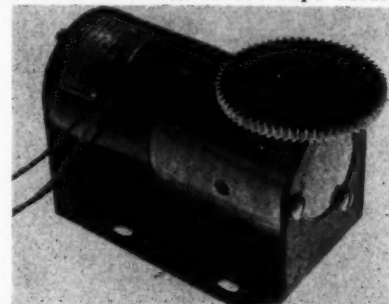


ature over a 200-1000°C range with 5° accuracy; has less than one-third the volume and weight of comparable vacuum-tube units; warms up instantaneously. Its 2-sec full-scale response makes it highly suitable for multiple-thermocouple monitoring with any number of chromel-alumel TC's or with modification, with airborne time-temperature recorders.—*Ford Instrument Co., Div. of Sperry Rand Corp., 31-10 Thompson Ave., Long Island City 1, N. Y.*

For more information circle 355 on inquiry card.

GEARHEAD MOTOR

New 400-cycle 115-v right-angle gear-head motor with output speed of 75 RPM is designed for tape record-



ing, aircraft and other applications requiring moderate torque at low speeds.—*Air-Marine Motors, Inc., 369 Bayview Ave., Amityville, N. Y.*

For more information circle 356 on inquiry card.

GENERAL ELECTRIC

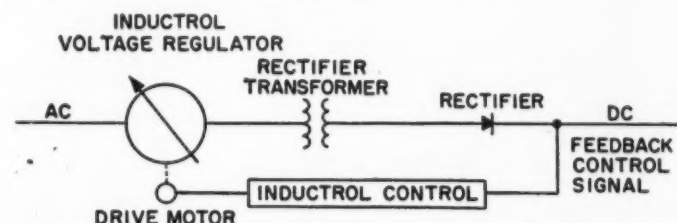
VOLTAGE REGULATION IDEA FILE

by C. A. Neumann



ENGINEERING DESIGN IDEA: A.C. Controls D.C.

General Electric Inductrol* a-c induction voltage regulators can control d-c voltage or current. Here's how:



Inductrol regulators compensate for a-c line variations, rectifier aging effects, regulation as d-c load current varies, hold voltage (or current) to $\pm 1\%$.

DESIGN BENEFITS: Inductrol regulator drift-free controls always keep voltage settings at desired level. Cost is low.

RADAR APPLICATION IDEA:

New England radar manufacturer uses three single-phase Inductrol voltage regulators to give precise individual phase regulation, hold voltage to $\pm 1\%$. In addition a three-phase, motor-operated, manually-controlled Inductrol regulator is used for tube warm-up. Power can be increased by raising voltage from 0 to 600 in either two seconds or 30 seconds.

DESIGN BENEFITS: Easy-to-install, Inductrol voltage regulators introduce no waveform distortion into electronic systems.

COMPUTER APPLICATION IDEA:

Massachusetts computer manufacturer got line stability and proper tube warm-up by using both voltage stabilizer and voltage regulator. One Inductrol voltage regulator now does both jobs.

DESIGN BENEFITS: Inductrol voltage regulators have an excellent space factor, require little maintenance. They neither affect, nor are affected by, system power factor.

HEAT TEST IDEA:

Boston electronics firm uses battery of infrared quartz lamps to simulate missile in-flight heat conditions. Lamps, energized suddenly on this 208-volt circuit produced rapid heat, but lack of warm-up time caused expensive lamp mortality. A complicated and expensive wiring-switching arrangement was considered, discarded in favor of 3-phase automatic Inductrol voltage regulator.

DESIGN BENEFITS: Inductrol voltage regulators have no brushes to maintain or replace; are rugged, designed for long life; are extremely accurate and reliable.

FOR MORE INFORMATION write Section 425-8, General Electric Company, Schenectady 5, N. Y.

*Trade mark of General Electric Company for Induction Voltage Regulators.

Progress Is Our Most Important Product

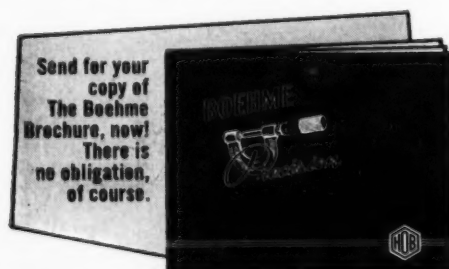
GENERAL ELECTRIC

For more information circle 28 on inquiry card.



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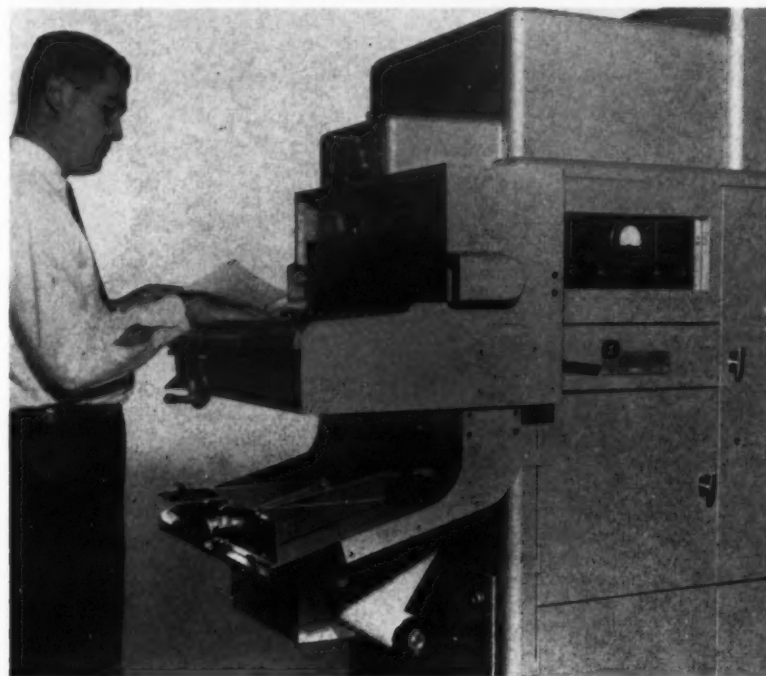
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For more information circle 29 on inquiry card.

AUTOMATIC XEROGRAPHY



New Model 2 XeroX Copyflo continuous printer will provide—from one or a series of original documents—dry, positive prints up to 11 inches wide at the rate of 20 feet a minute. Reproduction is done by xerography, a fast, dry, electrostatic copying method producing direct, positive prints. In Copyflo Model 2, original documents are fed by hand into the

throat of a continuous belt table that carries the document through camera-exposure stage and deposits it back at the operator's fingertips. Can also process continuous paper offset masters in roll from at 20 feet a minute. The masters are later cut apart for mounting on offset duplicators.—*The Haloid Co., Rochester 3, N. Y.*

For more information circle 357 on inquiry card.

ALIGNMENT TESTER

New Model IF Vari-Sweep complete alignment instrument retains advantages of standard fixed-band alignment unit but adds flexibility

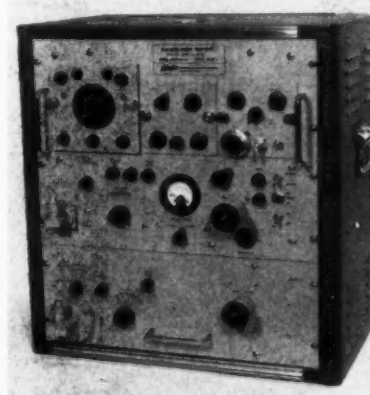


features: (1) Continuously-variable center frequency from 4 to 120 mc with direct-reading calibrated dial; (2) continuously-variable sweep widths from the kilocycle range to 40 mc; and (3) continuously-variable frequency marker from 2 to 135 mc giving direct readings from an individually calibrated frequency dial. "Birdie pip" marker is easily distinguished from fixed pulse-type marks.—*Kay Electric Co., 14 Maple Ave., Pine Brook, N. J.*

For more information circle 358 on inquiry card.

RADAR TEST SET

New Model W-909-1A provides all the instrumentation necessary for complete X band and C band check-

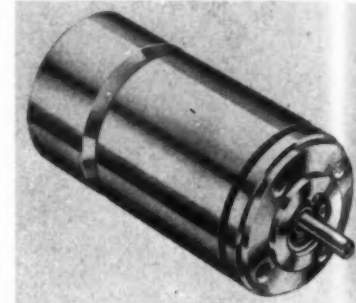


out of radar and other transmitters in field or on production line. For each band it contains spectrum analyzer, power monitor, direct-reading frequency meter and signal generator. Simplified operation through color-coded sections, direct-reading dials, quick-change band switch and calibrated attenuator dial.—*Western Div., Kearfott Co., Inc., 253 N. Vinado Ave., Pasadena, Calif.*

For more information circle 359 on inquiry card.

DAMPED SERVOMOTOR

New damped Size 11 servomotor has electromagnetic viscous-damping adjustable from 5 to 90 dyne-cm-sec.

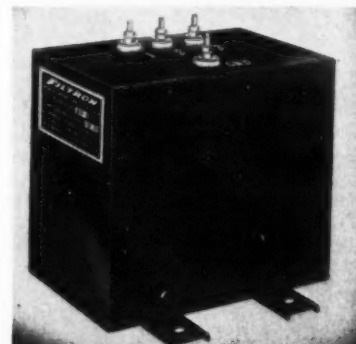


radian. Temperature range is -55° to $+160^{\circ}\text{C}$ ambient; fixed windings operate from a 115-v 400-cycle source; control windings are for transistorized amplifier input. Other windings can be supplied on custom specifications.—*Beckman/Helipot Corp., Newport Beach, Calif.*

For more information circle 360 on inquiry card.

PF CORRECTION COILS

New series FSR-800 power-factor correction coils reduce capacitive cur-

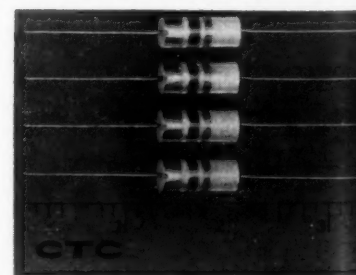


rent in filtered power lines of screen rooms in cases where limited generator output requires a reduction in reactive current.—*Filtron Co., Inc., 131-05 Fowler Ave., Flushing 55, N.Y.*

For more information circle 361 on inquiry card.

ENCAPSULATED CHOKES

New family of epoxy-encapsulated chokes comprises 13 units ranging in values from 1.1 through 120 micro-



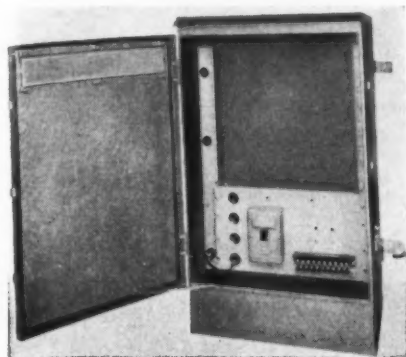
henries following preferred values. All are $\frac{1}{8}$ " dia and $\frac{3}{4}$ " long; color-coded for value identification and available from stock.—*Cambridge Thermionic Corp., 445 Concord Ave., Cambridge 38, Mass.*

For more information circle 362 on inquiry card.

MILITARY AUTOMATION

WEATHERIZED CABINET

New Type 461 pole-mounting cabinets provide for "weatherized" protection of carrier communications equipment.

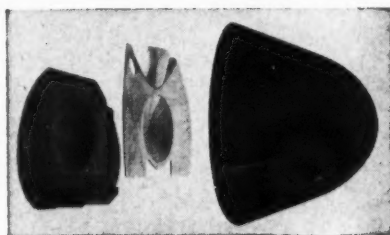


ment or other 19-inch panel-mounted electronic equipment. Auxiliary Type 486 power panel (consisting of circuit breaker, four power receptacles and one 10-terminal carbon-block protector) is also available as accessory equipment.—*Warren Mfg. Co., Inc., 10 Lake Ave., Littleton, Mass.*

For more information circle 363 on inquiry card.

RADOME ABSORBER KITS

New line of X- or C-band Radome and Microwave Absorber Kits, for all-weather radar installations on light aircraft, is made up of three items:



radome, microwave absorber and attachment hardware. Easy access to all components for maintenance or for safety inspection is assured. Military and CAA specifications are met where applicable.—*McMillan Industrial Corp., Brownville Ave., Ipswich, Mass.*

For more information circle 364 on inquiry card.

OPTICAL STRAIN GAGE

New optical strain gage measures strain characteristics of materials at temperatures up to 1000°F. Designed for precise measurement of tension and compression strains as small as 0.000004", gage consists of two essential parts—Auto-Collimator and Extensometer (or gage). Strain being measured rocks mirror within extensometer; degree of rocking is then measured by Auto-Collimator.—*American Instrument Co., 8030 Georgia Ave., Silver Spring, Md.*

For more information circle 365 on inquiry card.

GYRO TILT TABLE



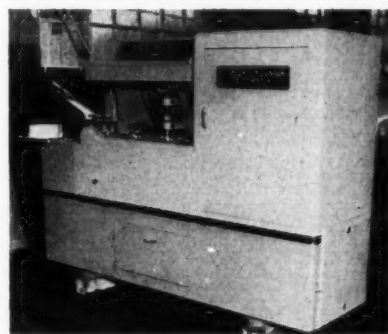
New Model 01-0001 servo-controlled tilt table provides functional checking of a missile's internal guidance gyros. It generates angular position and velocity inputs to the gyro and consists of: (1) Electro-mechanical assembly; a two-gimbaled tilt-table capable of carrying a 125-lb. guidance package driven through precision gearing by 2 two-phased 400-cycle servo motors (one on each gimbal).

Gimbal position is measured to 30" of arc. Angular velocities are measured to 0.025°/sec. Velocity range is from 0.1°/sec to 35°/sec. (2) Electronic pre-amplifiers & pick-off amplifiers. (3) Quadrature rejection unit (for use in carrier-type servo systems) and (4) trailer.—*Thompson Products, Inc., 2196 Clarkwood Rd., Cleveland 3, Ohio.*

For more information circle 366 on inquiry card.

AUTOMATIC FILM MOUNTER

New Filmsort mouter automatically transfers microfilm from reels to Filmsort aperture cards. Now in use in engineering sections of major mili-



tary services, it handles 2,000 mountings an hour to speed mounting of microfilms and other large volume documents. Equipment has automatic detection system which immediately stops the mouter when any one of the operational stations fails because of card imperfection, etc.—*Filmsort Division of Dexter Folder Co., Pearl River, N. Y.*

For more information circle 367 on inquiry card.

GLASS CAPACITORS

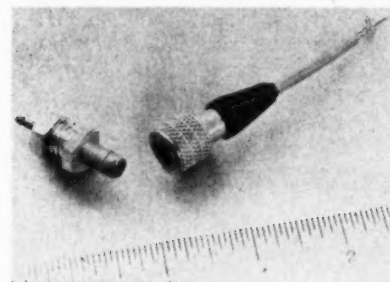
New WL capacitors for printed circuit boards feature fixed temperature-coefficient, high insulation-resistance, low dielectric-absorption, and

ability to operate under high humidity conditions and high temperatures. Now being used in the U. S. Army receiver-transmitter helmets; WL-4 is 0.3 by 0.3 inch size in capacitances up to 1000 uuf at 300 v. The WL-5 is 0.3 x 0.5 inch size in capacitances up to 2200 uuf.—*Corning Glass Works, Corning, N. Y.*

For more information circle 368 on inquiry card.

SUB-MINIATURE COAXIAL CONNECTOR

New sub-miniature snap-lock coaxial cable connector and mating receptacle is available in 50, 75, and

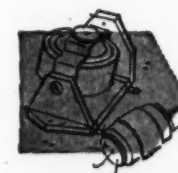
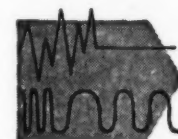
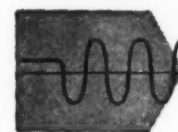
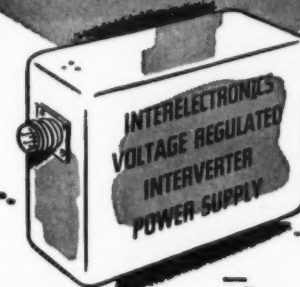


95 ohm sizes. Cable plug is spring loaded and snaps into position to engage its special receptacle firmly. Plug cannot be removed by pulling on cable or by vibration, but only by sliding knurled sleeve toward cable end.—*Automation-Engineering Corp., 723 Sonora Ave., Glendale 1, Calif.*

For more information circle 369 on inquiry card.

NEW!

DC to DC and DC to AC
solid-state power converters
voltage regulated, frequency
controlled, for missiles,
telemetry, gyros, servos



Interelectronics Inverter solid-state thyatron-like elements and magnetic components convert DC to any number of voltage regulated or controlled frequency AC or filtered DC outputs from 1 to 1800 watts. Light weight, compact, 90% or better conversion efficiency.

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Now in use in major missiles, powering telemetry transmitters, radar beacons, electronic equipment. Single and polyphase AC output units now power airborne and marine missile gyros, synchros, servos, magnetic amplifiers.

Interelectronics — first and most experienced in the DC input solid-state power supply field, produces its own solid-state gating elements, all magnetic components, has the most complete facilities and know-how—has designed and delivered more working KVA than any other firm!

For complete engineering data write Inter-electronics today, or call Ludlow 4-6200 in N. Y.

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For more information circle 30 on inquiry card.



In every choice situation

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another outstanding Hi-G relay



HG-E2

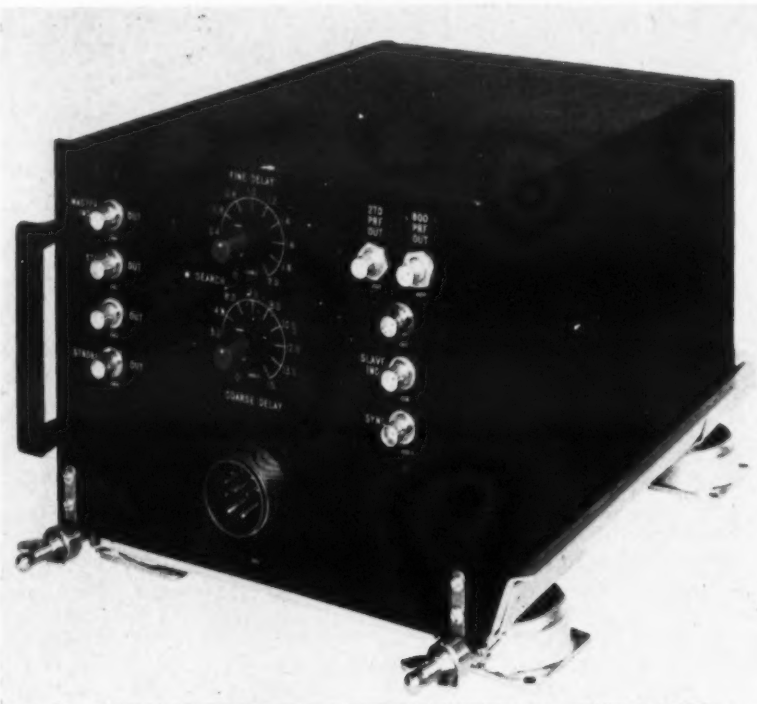
Sub-miniature... hermetically sealed... space saving, this HG-E2 relay measures 1" square by 1/2" ... meets MIL-R-5757C. Designed for operating temperatures up to 125°C. with long-life characteristics at rated contact loads of 2 amps at 28 Vdc or 115 Vac. Coil resistance ranges of 50 to 10,000 ohms. Hook terminals or straight pins for plug-in and printed circuit applications are standard. Available in Form A, B, or C contact arrangement with maximum of two poles... for AC operation with internally mounted silicone rectifiers.

Today... find out more about the complete line of Hi-G sub-miniature relays.



BRADLEY FIELD • WINDSOR LOCKS, CONN.
For more information circle 31 on inquiry card.

ELECTRONIC TRIGGER



New type electronic trigger, providing eight separate pulse outputs in sequence, is a universal piece of equipment using line frequency for synchronization. It is used as a control or coordinating device for individual radar units, communications, and other electronic systems using 400-cycle power source. Occupies only 0.65 cubic feet of space and weighs 16 pounds when installed on standard

aircraft shock-mounted rack. Coordination of electronic equipment on a single craft minimizes error in radar ranges and eliminates radar scope "jitter" and other mutual interference between equipment. Can also be used as a universal laboratory tool for equipment testing.—Phileo Corp., 4700 Wissahickon Ave., Philadelphia 44, Penna.

For more information circle 370 on inquiry card.

GALVANOMETER AMPLIFIER

New galvanometer amplifier incorporating three cut-off filters is used in accelerometer amplifier and as a general purpose laboratory amplifier. Claimed features are a frequency range of 2 to 10,000 cps, input impedance over 100 megohms and a gain of 85 decibels with an overall size of 8" x 4" x 5" high. Total harmonic distortion less than 1% and total current drain less than 35 ma.—Nevada Air Products Co., Electronics and Guided Missile Div., North Valley Road, Reno, Nev.

For more information circle 371 on inquiry card.

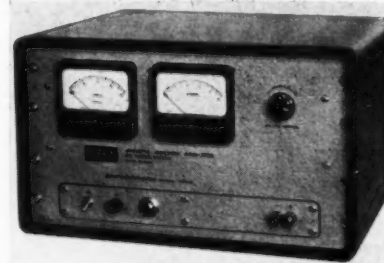
GRAPHIC RECORDING FILM

New opaque-coated polyester film featuring easy duplication, projection or optical evaluation is used to transcribe multichannel test data. White coating turns transparent under stylus; when grid-printed with solvent ink may be duplicated or projected; marginal notes are typed without ribbon.—Dept. Q, Technical Paper Co. Inc., 2430 Linden Ave., East, Linden, N. J.

For more information circle 372 on inquiry card.

TRANSISTORIZED HI-POWER SUPPLY

New transistorized regulated dc power supplies with voltages from 3 to 350 volts, and current ratings from



50 milliamperes to 20 amperes, combine magnetic-amplifier pre-regulators with unique transistor circuitry as the final element of regulation. Are said to give performance equalling or excelling vacuum tube or straight magnetic amplifier type power supplies. Features: power levels up to 1 KW, high efficiency, low heat dissipation, instant warm-up time and extremely long life.—Perkin Engineering Corp., 345 Kansas St., El Segundo, Calif.

For more information circle 373 on inquiry card.

ELECTROHYDRAULIC-VALVE AMPLIFIERS

New transistorized Electrohydraulic-Valve Amplifiers deliver 8 ma differential current to 2000-ohm center-tapped load; has 30 dc power gain and will operate in 170°F ambient, using either 60- or 40-cycle excitation. Envelope of 1" x 2" x 3" includes variable gain, balance and quiescent controls.—Control Specialist Div., Kelsey-Hayes Co., Inglewood 1, Calif. For more information circle 374 on inquiry card.

WEDGE-ACTION RELAY

New Mark II is a 2-ampere, 6-PDT miniature hermetically sealed relay which meets or exceeds specifications

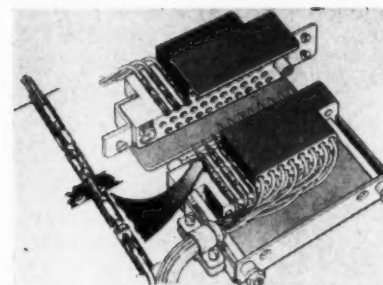


MIL-R-5757C and MIL-R-25018. Employs "wedge action" principle to achieve positive, self-cleaning contact and high resistance to shock and vibration. Basic unit has a 26.5-volt coil, but other values can be provided.—Electro Tec Corp., So. Hackensack, N. J.

For more information circle 375 on inquiry card.

CONNECTORS WITH "SNAP-IN" CONTACTS

New series of rectangular electrical connectors, featuring removable "snap-in" contacts, have retention springs which permit solderless at-

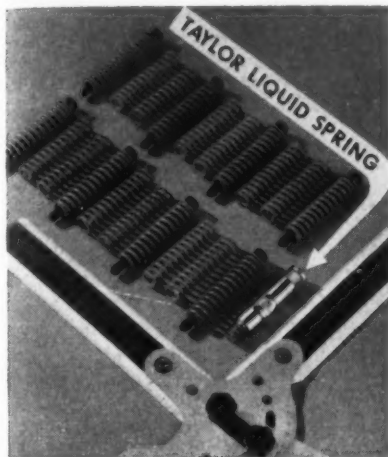


tachment of contacts to wires to allow easy replacement or re-arrangement. Hood is made in two parts to facilitate assembly and contact replacement. Available in 34, 42, 50 and other standard contact capacities. Equals or exceeds specifications of MIL-C-8384A.—Consolidated Electrodynamics Corp., 740 Salem St., Glendale, Calif.

For more information circle 376 on inquiry card.

LIQUID SPRING

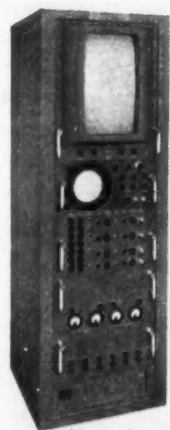
New miniature ($\frac{1}{2}$ " diameter) self-contained Model 416 liquid spring develops 800 lbs. force at $\frac{1}{4}$ " stroke with an 80 lb. preload; is only 2" long plus $\frac{3}{8}$ " mounting stud. Producing



the force of 20 standard coil springs of the same diameter and length. Liquid Springs and Spring Shoks are rated up to 50,000 lbs. In military applications, reduction in size and weight, plus optional built-in shock absorber can solve many operational problems.—Taylor Devices Inc., 188 Main St., North Tonawanda, N. Y.

For more information circle 377 on inquiry card.

COMMUTATED DATA DISPLAY



New ECS Model C-208 large-screen display, built to MIL Standards, provides a "quick look" at 7 commutated data channels containing information from as many as 189 parameters on the readiness of a telemetering system for flight. Data are automatically synchronized and

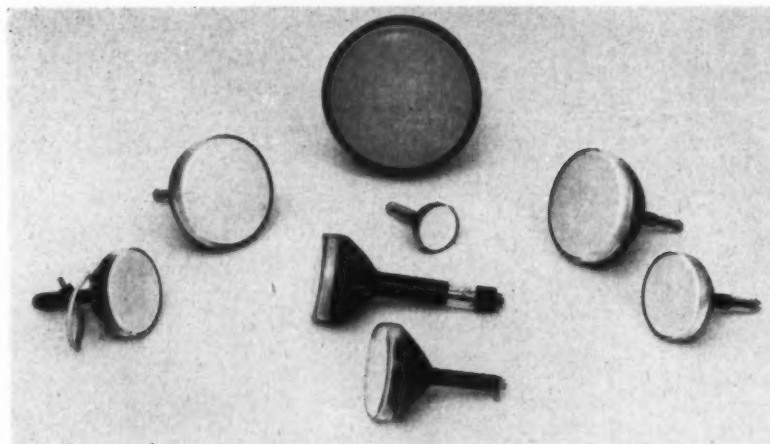
displayed on as many as 7 separate traces on a 21-inch cathode ray tube, with additional provisions for viewing any portion of any trace on an auxiliary 7-inch cathode ray tube.—Electronic Control Systems, Inc., 2136 Westwood Blvd., Los Angeles 25, Calif.

For more information circle 378 on inquiry card.

THERMISTOR MOUNTS

New FXR Series 216 Broadband Thermistor Mounts now cover the full waveguide frequency range from 1,120 to 40,000 mc/sec. For use in conjunction with power meters or other bridge circuits utilizing a thermistor bead mounted inside a section of ridged waveguide, these are said to

SHORT RADAR TUBES

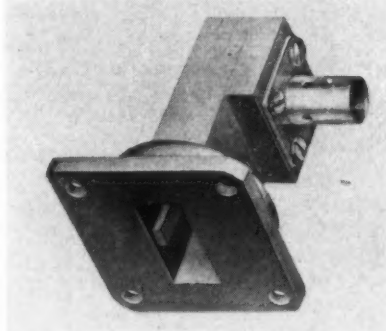


New line of radar display tubes, reducing space requirements by as much as six inches (overall length) for airborne installations, are said to be particularly valuable for cockpit radar installations. B1144 is identical to 5BCP but a specially designed

potted lead allows high voltage operation at 18 kv for airborne daylight viewing applications. All "space-saver" radar tubes feature magnetic deflection.—Allen B. DuMont Labs., Inc., 750 Bloomfield Ave., Clifton, N. J.

For more information circle 379 on inquiry card.

provide a constant characteristic impedance over a broad frequency range, making adjustable tuning elements unnecessary. Nominal sensi-

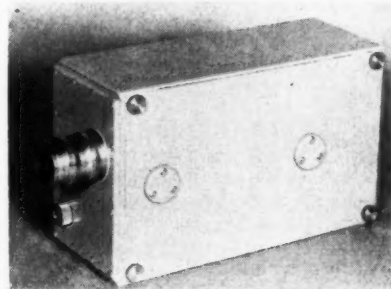


tivity is 10 ohms/mw, sufficient to detect powers as low as 10 microwatts.—Electronics & X-Ray Div., F-R Machine Works, Inc., 26-12 Borough Pl., Woodside 77, N. Y.

For more information circle 380 on inquiry card.

TEST CAMERA

New Model HS-16A intermediate high-speed photographic recorder with 200-foot 16-mm film capacity has day-



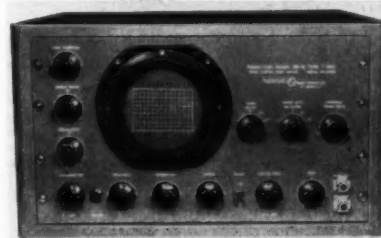
light-loading spools designed to operate remotely while mounted on aircraft, missiles, sleds, or any vehicle

where photographic information is required for test or documentary purposes. Timing lights, boresight, mount, "C" lenses, carrying case, interchangeable shutters, and speed change gears are available accessories.—Photo Inst. Div., Benson-Lehner Corp., 11930 Olympic Blvd., Los Angeles 64, Calif.

For more information circle 381 on inquiry card.

SPECTRUM ANALYZER

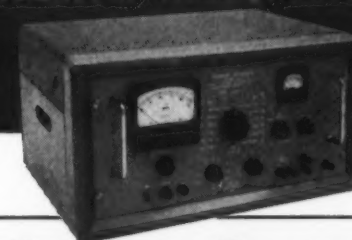
New Panalyzer model SB-12 Type T-100 can be used to observe signals anywhere in the spectrum up to 1,000 mc by means of an external signal



generator and an internal aperiodic mixer which translate the spectrum segment to be analyzed down to its 450-550 kc input band. Actually an automatic scanning superheterodyne receiver, the SB-12 can be used to investigate pulsed RF signals, analyze AM and FM transmitters, spot spurious oscillations and modulation, monitor communications and telemetering channels, test industrial RF equipment, diathermy and electro-surgical instruments, and a wide variety of other laboratory and production test problems.—Panoramic Radio Products Inc., 10 So. Second St., Mount Vernon, N. Y.

For more information circle 382 on inquiry card.

NORTH HILL'S MODEL CG-1



Constant Current 1 ma to 30 amps

- Rapid manual or automatic switching to desired current levels.
- High accuracy and stability.
- Current can be electronically switched, pulsed, swept, modulated and programmed.

Ideal for Rapid Testing of:

- Semiconductors
- Electromagnetic Components
- Other Current-Sensitive Devices

- Model CG-1 1 ma — 600 ma
- Model CG-11 Transistorized .05 — 5 amps
- Model CG-12 Transistorized .5 — 30 amps

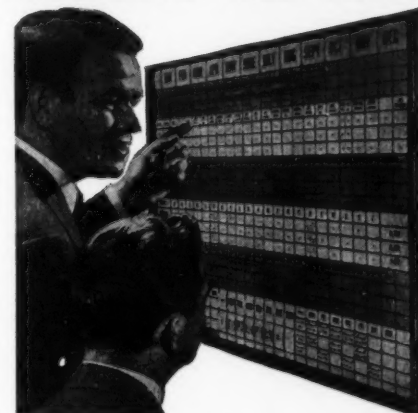
For further data,
write for Bulletin E-1M

nh

NORTH HILLS ELECTRIC CO., INC.
402 Sagamore Ave., Mineola, N.Y., PI 7-0555

For more information circle 32 on inquiry card.

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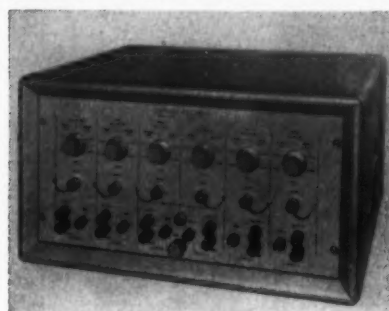
GRAPHIC SYSTEMS

55 West 42nd Street • New York 36, N. Y.

For more information circle 33 on inquiry card.

CATHODE FOLLOWERS

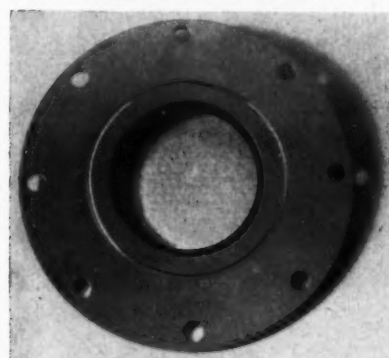
New single-channel Model 4000 and six-channel Model 4006 followers, designed to couple barium titanate ac-



celerometers to standard test equipment, feature 5000-megohm input resistance and 290-ohm output resistance, gain of 0.98, and frequency coverage from 0.02 cps to 1 mc.—*Columbia Research Labs, McDade Blvd. and Bullens Lane, Woodlyn, Pa.* For more information circle 383 on inquiry card.

S-BAND WINDOW

New BL713 pressurizing window for the S-band can be used on RG-48/U waveguide and UG54A/U choke



flange. Frequency range is from 2600 to 3700 mc with a pressure differential of 30 psi.—*Bomac Laboratories, Inc., Salem Rd., Beverly, Mass.* For more information circle 384 on inquiry card.

POWER SUPPLIES

New sub-chassis power supply illustrated is produced in Model PS-S150 (with output of 150-volts 150-ma

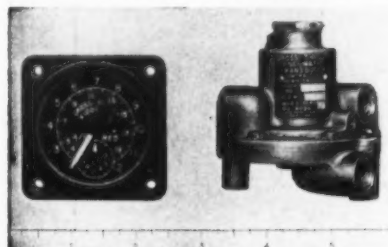


de, 6.3-volts 6-amp ac) and Model PS-S300 (with 300-vdc output). Both models use inputs of 115 volts, 60 cps. DC regulation claimed is 0.5% for 10% line change; 1.0% for no load to full load.—*The Reflectone Corp., Stamford, Conn.*

For more information circle 385 on inquiry card.

JET THRUST METER

New Type 141LA1 Gross Thrust Measuring System evaluates gross thrust as estimated by the formula $F_g = K (1.26P_f - P_o)$ on a 300° arc,



with multiturn vernier for interpolation between 1000 lb. dial graduations. Thrust evaluation is particularly important prior to takeoff for jet transports. System has passed qualification requirements of a military installation; weighs only 1.5 lbs.—*Manning, Maxwell & Moore, Inc., Aircraft Products Div., Danbury, Conn.*

For more information circle 386 on inquiry card.

HYDRAULIC CONTROL

New 1701 Series hydraulic control valves provide smooth and positive 2-way control in hydraulic pressure systems by actuating a cylindrical



screw-type slide plunger via a 28-v dc motor-driven 2-stage gear train. Qualification-tested per MIL-V-5529 A and MIL-E-5272 A, it also features one-piece body to eliminate leaks; automatic current shut-off; small size—5.45" long; easy inspection and maintenance.—*Lyndon Aircraft, Inc., 140-49 Clifford St., Newark, N. J.*

For more information circle 387 on inquiry card.

MICROWAVE THERMISTOR

New MA-677 Thermistor, for sensitive power measurements from 10 to 12,400 mc, is mechanically inter-

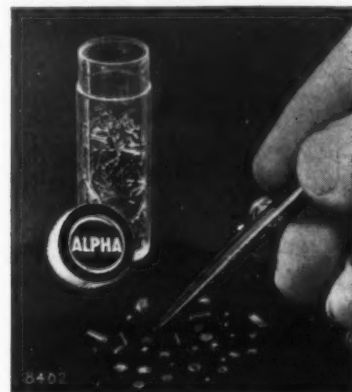


changeable with 1N21 and 1N23 silicon mixer diodes and 1N32 and MA-490 video diodes, allowing its use in coaxial or waveguide holders designed for these crystals. Other characteristics: Operating resistance—200 ohms, bias—6 ma (approx), power rating—10 mw.—*Microwave Associates, Inc., Burlington, Mass.*

For more information circle 388 on inquiry card.

PREFORMED SEMI-CONDUCTOR DOPING ELEMENTS & ALLOYS

New high-purity metals department has full-scale production of all shapes of elements and alloys found in groups 3 and 5 of the periodic chart,



such as gallium, indium, aluminum, antimony and arsenic.—*Alpha Metals, Inc., 56 Water St., Jersey City, N. J.* For more information circle 389 on inquiry card.

TIME ACCELERATION SWITCH

New rugged and compact acceleration-time integrating switch for missile and rocket applications

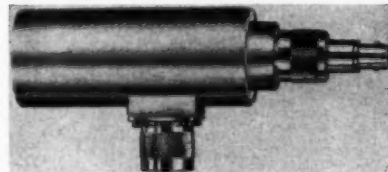


actuates when sustained acceleration in excess of internal bias is applied. Contact closure occurs in present unit when missile reaches approximately 460 ft/sec velocity under sustained accelerations between 4 and 15 G's. Is adaptable to a wide range of acceleration and time parameters to satisfy specific requirements.—*The Magnavox Co., 2131 Bueter Rd., Fort Wayne, Ind.*

For more information circle 390 on inquiry card.

UHF DETECTOR MOUNT

New Model C 1300 (4000-8500 mc, illus.) and Model C 1400 (8000-12000 mc) crystal detector mounts, have

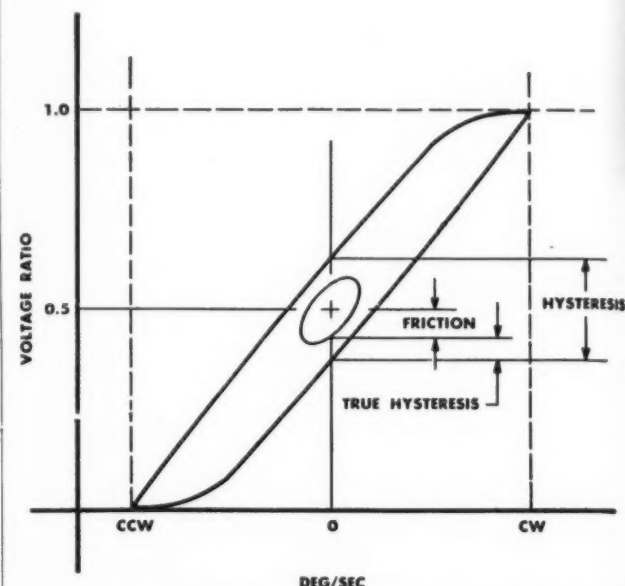


been added to the AEL 1000 series "Blue Line" Crystal Detector Mount family. The entire range from 50 to 12000 mc is now served by these light-weight high-sensitivity crystal holders.—*American Electronic Labs, Inc., 121 N. 7th St., Philadelphia, Penna.*

For more information circle 391 on inquiry card.

Calibrating Gyros Without Tapping

Although it is a general practice to use tapping for reducing the effects of friction during gyro calibrating, the non-tapping or hysteresis-loop-type of calibrations provide a truer performance curve. The



Hysteresis loop illustrates the amount of friction and true hysteresis that is present in a gyroscope. Located inside the hysteresis loop, the small curve is obtained by testing five percent of the full-scale value. At this small rate, true hysteresis will be negligible and the resulting curve is the friction present in the gyro.

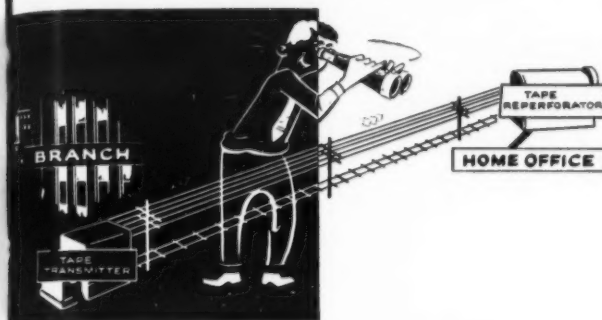
tapping system offers a possibility of error in that tapping or its equivalent does not occur consistently during normal operation of the instrument and it is almost impossible to have repeatability in these tests. Also, while tapping reduces the friction effect, it may not completely eliminate it. Calibration of a gyro without external tapping provides the opportunity of viewing the gyro output at its lowest level of performance. Any vibration, which exists in any aircraft or missile application, will reduce the effects of friction and improved performance can be expected. (From new 8-page July, 1957, issue of "Giannini Technical Notes", G. M. Giannini & Co., Inc., 918 E. Green St., Pasadena, Calif.)

For this literature circle 105 on inquiry card.

Punched Tape

Heavy-duty "Flexowriter" automatic writing machine punches tape at the same time a document is typed; result is a visible proof and coded tape which stores information for later use. The Flexowriter reads tape and types information automatically at 100 words

per minute, or duplicate tape at 100 words per minute. Flexowriter opens the door to the automatic preparation of letters, envelopes, invoices, statements, publicity releases, contracts, policies, proposals, stencils, pa-

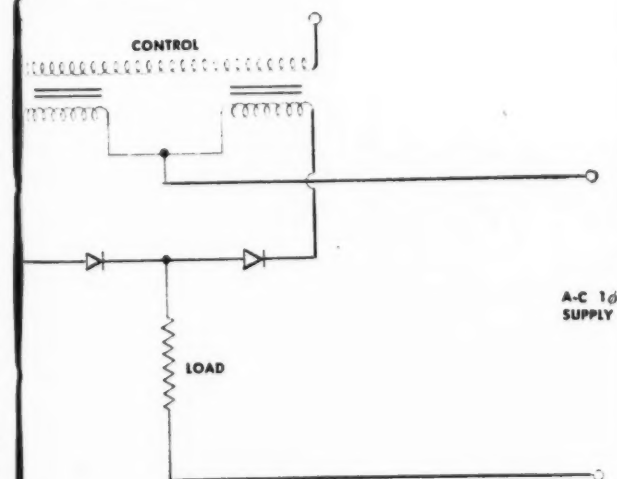


per plates, spirit masters, gelatin masters, address stencils, vouchers, checks, price lists, directories and more. From 24-page Bulletin SP-8629R, Commercial Controls Corp., Subsidiary of Friden Calculating Machine Co., Inc., 1 Leighton Ave., Rochester 2, N. Y.)

For this literature circle 106 on inquiry card.

Standard Reactors

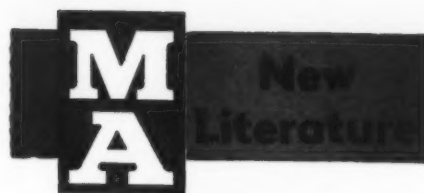
Control manufactures a complete line of 240-volt and 120-volt saturable reactors. Industrial designers have a choice of a range of standard sizes. This permits them to design around specific units, and provides the faster delivery and lower costs offered by standardization.



Control reactors have high power gains. Six ampere-turns will control nearly 2,000 watts in the largest of these standard reactor assemblies. Power outputs range from 50 to 2,000 watts, with only 2 ampere-turns being required for control of the smallest units.

Control reactors are designed for large power amplification of low-level signals. One of the most commonly used circuits for high gain is the single-ended, self-saturating doubler circuit (shown here with a-c output). (From new 32-page Catalog R-10, Control, Division of Magnetics, Inc., Butler, Penna.)

For this literature circle 107 on inquiry card.



TUBES, TRANSISTORS

TRAVELING WAVE TUBE principles are explained in non-mathematical terms, with diagrams and applications in 6-page Technical Bulletin No. 1.—Electronic Tube Div., Sperry Gyroscope Co., Great Neck, N. Y.

Circle 401 on inquiry card.

POWER TRANSISTOR. 4-page Bulletin B-214 gives what is believed to be the first military spec for a power transistor: issued by Signal Corps for new Cleve Type 2N297, includes complete data and test circuit diagrams covering Mil Spec.—Cleve Transistor Products, 241 Crescent St., Waltham 54, Mass.

Circle 402 on inquiry card.

MEDIUM-MU TETRODE. 4-page technical bulletin describes new RCA-5CQ8 multi-unit tube for TV receivers utilizing 40-mc IF circuits.—Radio Corporation of America, Harrison, N. J.

Circle 403 on inquiry card.

ETCHED PARTS including cathodes and other components for use in electron tubes; aperture masks to guide the electron beams in color television tubes and evaporating masks used in the manufacture of transistors, anodes and letter and number characters for vacuum tubes are described in new Bulletin 90.—Superior Tube Co., Norristown, Pa.

Circle 404 on inquiry card.

TRANSISTOR EQUIPMENT comprising ERA's complete line of products, including transistorized inverters, converters, high current power supplies, and test equipment, are described in 10-page folder-catalog.—Electronic Research Associates, Inc., 67 East Centre St., Nutley 10, N. J.

Circle 405 on inquiry card.

POTENTIOMETERS, RESISTORS

PICK-OFF POTS. 2-page bulletin entitled "Pick-off and Sector Potentiometers for Aircraft and Missile Control Systems" covers units designed to operate in damping fluids, and in temperatures in excess of 150°C.—Norden-Ketay Corp., Commerce Rd., Stamford, Conn.

Circle 406 on inquiry card.

POT. 2-page Bulletin 149 describes new ultra-miniature potentiometer for domestic and military applications.—Ohmite Mfg. Co., 3638 Howard St., Skokie, Ill.

Circle 407 on inquiry card.

MINIATURE POTENTIOMETERS. Type AS, molded composition construction, including specifications, resistance values, dimensions and prices, are described in new 2-page Bulletin 149.—Ohmite Manufacturing Co., 3638 Howard St., Skokie, Ill.

Circle 454 on inquiry card.

ELECTRONIC COMPONENTS

COMPUTER CAPACITORS are described in 4-page Engineering Bulletin CQM on high-reliability electrolytics.—Pyramid Electric Co., 1445 Hudson Blvd., North Bergen, N. J.

Circle 408 on inquiry card.

AIRCRAFT TRANSFORMERS and maker's 400-cycle instruments, available in single and three phase models, are subject of 4-page Bulletin A-1028.—Electrosolids Corp., 7436 Varna Ave., N. Hollywood, Calif.

Circle 409 on inquiry card.

FILTERS for aircraft and missiles are covered in 6-page catalog 54-100 which describes line-type, cell-type and other units using Poro-Klean sintered stainless-steel material.—Cuno Engineering Corp., South Vine St., Meriden, Conn.

Circle 410 on inquiry card.

COAX COMPONENTS. 20-page catalog describes coaxial switches and relays for radio and video.—Danbury-Knudsen Inc., Danbury, Conn.

Circle 411 on inquiry card.

INERTIA SWITCH. 2-page bulletin gives complete specs of a new compact inertia switch for aircraft, electronic instruments, etc.—Safe Lighting Inc., 527 Lexington Ave., New York, N. Y.

Circle 412 on inquiry card.

EXPLOSIVE ORDNANCE. 4-page Condensed Data Bulletin CD-1-57 covers electric primers, squibs and igniters, explosive bolts, CAD cartridges, gas generators, etc.—McCormick Selph Associates, Hollister Airport, Hollister, Calif.

Circle 413 on inquiry card.

AIRCRAFT CIRCUIT BREAKER specifications and characteristics are given in—20-page de-luxe brochure which also describes company's R&D facilities.—Mechanical Products, Inc., 1824 River St., Jackson, Mich.

Circle 414 on inquiry card.

REDUCTION OF INTERFERENCE through use of bandpass crystal filter is subject of reprint of Technical Memorandum RADCM-56-33 by Frederick Raymond.—Hycon Eastern, 75 Cambridge Pkwy, Cambridge, 42, Mass.

Circle 415 on inquiry card.

DYNAMOTOR. Bulletin 15F5 is a data sheet on a dynamotor for use in guided missiles—Induction Motors Corp., 570 Main St., Westbury, N. Y.

Circle 416 on inquiry card.

CONNECTORS. Folder-type Bulletin 4003 and 2-page price list on high-performance miniature electrical connectors for extreme environmental applications.—Glendale Div., Consolidated Electrodynamics, 740 Salem St., Glendale 3, Calif.

Circle 417 on inquiry card.

AXIVANE FANS. 27v-dc, 400 and 60 cycle for aviation and electronic applications in 12-page spec. brochure.—Joy Mfg. Co., Oliver Bldg., Pittsburgh 22, Pa.

Circle 418 on inquiry card.

SYNCHRO PARAMETER 1-page definition chart for applications engineers—Theta Inst. Corp., 48 Pine St., E. Paterson, N. J.

Circle 419 on inquiry card.

MECHANICAL CLUTCHES, brakes and pulse amplifiers for remote positioning, tape stepping, sequence and scope photography in 9-page brochure—Digitronics Corporation, Albertson Ave., Albertson, L. I., N.Y.

Circle 420 on inquiry card.

ELECTRONIC INSTRUMENTS

SPECTROSCOPY. Product Bulletin No. A-8 describes a linear absorbance accessory for Model 21 infrared spectrophotometer.—Perkin-Elmer Corp., Main Ave., Norwalk, Conn.

Circle 421 on inquiry card.

DENSIMETER. 4-page Bulletin S4 describes Series 27 System for continuously measuring the specific gravity of a flowing fluid and, if desired, its mass flow-rate.—Potter Aeronautical Corp., U. S. Route #22, Union, N. J.

Circle 422 on inquiry card.

RECORDING INSTRUMENTATION. No. 561 recording oscillograph, which can survive shock accelerations above 1500 g's and No. 730 magnetic tape recorder, are described in 2-page bulletins.—Midwestern Instruments, 41st and Sheridan Rd., Tulsa, Okla.

Circle 423 on inquiry card.

TEMPERATURE RESISTOR for precision surface temperature measurements from -300°F to 400°F described in 2-page technical bulletin No. 137L—Trans-Sonics, Inc., P. O. Box 328, Lexington 73, Mass.

Circle 424 on inquiry card.

Pressure Transducers

TP-200 is a miniature unit, approximately 2" x 2" in size, for the measurement of absolute, differential or gage pressure with an over-all accuracy in the range of 2%. The pressure sensing element consists of

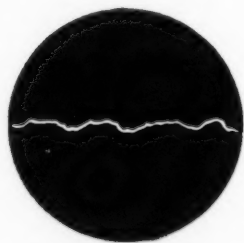
	TP-200 Type 948
Standard Pressure Ranges	0-5 PSI to 0-100 PSI
Standard Resistance Range, Ohms	1K to 40K
Overall Accuracy (All Errors)	2%
Standard Independent Linearity	±1.0%
Repeatability	0.4%
Hysteresis	0.5%
Operating Ambient Temperature	-55°C to +100°C

one or two capsular diaphragms which actuate one or two precision potentiometers. Both linear or functional outputs are available including linear outputs with altitude. Other types of a-c or d-c pick-offs can be supplied. TP-200 (Type 948) has been designed to meet applicable MIL environmental specifications. The specifications shown here can easily be modified to fit specialized applications. (From new 12-page *Condensed Components Catalog*, Fairchild Controls Corp., 225 Park Ave., Hicksville, L. I., N. Y.)

For this literature circle 108 on inquiry card.

Dynamotor Power Supplies

Only Carter tests each and every production Dynamotor model on an oscilloscope, in addition to normal input, output, and ripple meters. The oscilloscope is connected directly across the Dynamotor output with a 2 microfarad blocking condenser in the circuit, which permits only the small a-c component to be



Carter Genemotor model 4228VSC with perfect electrical characteristics. A-c ripple component unfiltered, 3.3 volts or 0.8%.

reproduced on the screen. In this manner, only electrically perfect units are approved, as small partial open windings, reversed commutator connections, brush sparking, high-resistance joints at commutator segments, and other defects are immediately detected on the screen. The oscilloscope tracings illustrate these defects which cannot be detected with the conventional meter method only. Together with the electrical insulation high-voltage breakdown tests on all production models, the oscilloscope test guarantees every Dynamotor to be electrically perfect. (From new 28-page *Catalog 157*, Carter Motor Co., 2711 W. George St., Chicago 18, Ill.)

For this literature circle 109 on inquiry card.

PANEL METERS that meet applicable sections of JAN-1-6 and MIL-M-6B are described in new 16-page catalog.—Waters Mfg. Inc., Boston Post Rd., Wayland, Mass.

Circle 425 on inquiry card.

MOISTURE MONITOR for controlling trace quantities of moisture in gases is described in new 5-page bulletin 1834A.—Consolidated Electrodynamics Corp., 300 No. Sierra Madre Villa, Pasadena, Calif.

Circle 426 on inquiry card.

HV TEST SETS including Sensitive Hipot Testers, Overpotential Test Sets, and continuous production type HV insulation test sets, are described in 8 page catalog.—Peschel Electronics, Inc., 13 Garden St., New Rochelle, N. Y.

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ELECTRONIC INSTRUMENTS. 4-page leaflet titled "Electronics at Work" covers CR tubes and scopes, pulse generators, TV systems, etc.—Allen B. DuMont Laboratories, Inc., 760 Bloomfield Ave., Clifton, N. J.

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DIGITAL AND ANALOG INSTRUMENTS are described in 8-page Short Form Catalog C-704 and in 4-page bulletin on latest models.—Beckman/Berkeley Div., 2200 Wright Ave., Richmond, Calif.

Circle 429 on inquiry card.

THERMISTORS. 10-page Catalog N. T-100 lists typical applications and circuitry, gives specs and characteristics, includes table of resistance ratio versus temperature.—Thermistor Div., Gulton Industries, Inc., 212 Durham Ave., Metuchen, N. J.

Circle 430 on inquiry card.

OSCILLATOR. 4-page technical bulletin describes Model 101C Ultra-stable Oscillator, a new 1-Mc signal source.—Hycon Eastern, Inc., 75 Cambridge Parkway, Cambridge 42, Mass.

Circle 431 on inquiry card.

PRECISION DELAY GENERATOR Type 6010, for laboratory applications requiring accurate, variable, time interval pulses, is described in new 4-page brochure—Burroughs Corp., Electronic Inst. Div., 1209 Vine St., Philadelphia 7, Pa.

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MAGNETIC COUNTERS. 4-page Bulletin AIC 1014 describes the world's smallest 3-and 4-digit magnetic counter for military and airborne applications.—Abrams Instrument Corp., 606 East Shiawassee St., Lansing 1, Mich.

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TELEMETERING SYSTEM and components (antennas, radar, guidance control, etc) are described in illustrated specification sheets. Also analog recorders and digital converters.—Radiation, Inc., P. O. Box 37, Melbourne, Fla.

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SHAFT ANGLE CONVERTERS (binary decimal coding) are described in 4-page bulletin.—Instrument Development Laboratories, Inc., 67 Mechanic St., Attleboro, Mass.

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SYSTEMS & FACILITIES

ENVIRONMENTAL TESTING laboratory services and facilities are described in 4-page brochure.—Associated Testing Lab., Inc., 414 Clinton Rd., Caldwell, N. J.

Circle 436 on inquiry card.

INFRARED GUIDANCE principles and systems are discussed in 20-page reprint of articles by Philip J. Klass.—Barnes Engineering Co., Stamford, Conn.

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TEST FACILITY. 4-page Bulletin GED-3339 describes GE's new aircraft electric systems lab to help speed development and qualification of complete systems.—General Electric Co., Schenectady 5, N. Y.

Circle 438 on inquiry card.

R&D FACILITIES for propulsion systems, ordnance, combustion, aerodynamics, etc., are described in 24-page de-luxe brochure which also outlines company's history since 1945.—Experiment Incorporated, Richmond 2, Va.

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CUSTOM TESTING SERVICES for manufacturers of Defense materiel are described in 12-page de-luxe brochure which also outlines R&D services.—Aerotest Labs, Inc., 129-11 18th Ave., College Point 56, N. Y.

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AVIATION PRODUCTS and services available through the Aviation Divisions, Kelsey-Hayes Co., are detailed in 32-page booklet.—Kelsey-Hayes Co., Detroit 32, Mich.

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"RACE" CHECKOUT system is explained in 6-page reprint of "Rapid Automatic Checkout Equipment for Maintenance of Weapon Systems" by D. Y. Keim.—Microwave Electronics Div., Sperry Gyroscope Co., Great Neck, N. Y.

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HUMIDITY CONTROL by electronic instruments for dehumidified storage or environmental test labs is described in new 8-page bulletin no. 2273.—American Instrument Co., 8030 Georgia Ave., Silver Spring, Md.

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NUCLEAR LABORATORY EQUIPMENT including a complete line of counting, sample preparation, personnel protection and survey, "hot lab" and storage equipment, as well as complete reference standards, are described in 28-page illustrated bulletin SN.—Technical Publications Dept., Tracerlab, Inc., 1601 Trapelo Rd., Waltham 54, Mass.

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MISCELLANEOUS

MAGNETIC TAPE in several new types, as well as technical data, are given in 8-page complete catalog of Scotch Brand Magnetic Instrumentation Tape, Titled "Physical Limitations of Magnetic Tape."—Minnesota Mining & Mfg. Co., Dept M7-218, St. Paul 6, Minn.

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DUPLICATING. Two 4-page brochures: one describes how Army Signal Corps saves \$500,000 a year on paperwork duplicating by using xerography; the other describes the A. C. Nielsen Company's use of a Foto-Flo photocopying machine.—The Haloid Co., Rochester 3, N. Y.

Circle 446 on inquiry card.

PHOTO MATERIALS for line reproduction are described in full technical details, and appropriate uses discussed, in 16-page Catalog K.—Gran Photo Products Inc., 19000 Detroit Ave., Cleveland 7, Ohio.

Circle 447 on inquiry card.

ARMY PACKAGE power reactor built at FT BELVOIR by ALCO is described in six-page article in Summe 1957 issue of ALCO PRODUCTS REVIEW.—Alco Products, Inc., P. O. Box 1065, Schenectady, N. Y.

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PRECISION CASTING. Varied applications and advantages, are covered in new 4-page folder.—Arwood Precision Casting Corp., 56 Washington St., Brooklyn 1, N. Y.

Circle 449 on inquiry card.

SHIELDING. 4-page data sheet 125 on magnetic hum and electrostatic shielding describes how to wrap square or rectangular components using Co-Netic flexible foil.—Magnetic Shield Div., Perfection Mica Co., 1322 No. Elston Ave., Chicago 22, Ill.

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SHIP STABILIZATION. By means of fins or hydroplanes projecting from the ship side and exerting an anti-rolling force is explained in new 4-page Bulletin D.7798.—Muirhead Instruments Inc., 677 Fifth Ave., New York 22, N. Y.

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PLASTICS used as rigid or resilient foams, casting resins, microwave absorbers or reflectors are described in 15-page brochure "Plastics for Electronics"—Emerson & Cuming, Inc., 869 Washington St., Canton, Mass.

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AIRCRAFT SERVICE and line test equipment for piston and jet engines is covered in 16-page Bulletin 251 which illustrates and describes 55 different sets, many of them portable or mobile.—Sprague Engineering Corp., Gardena, Calif.

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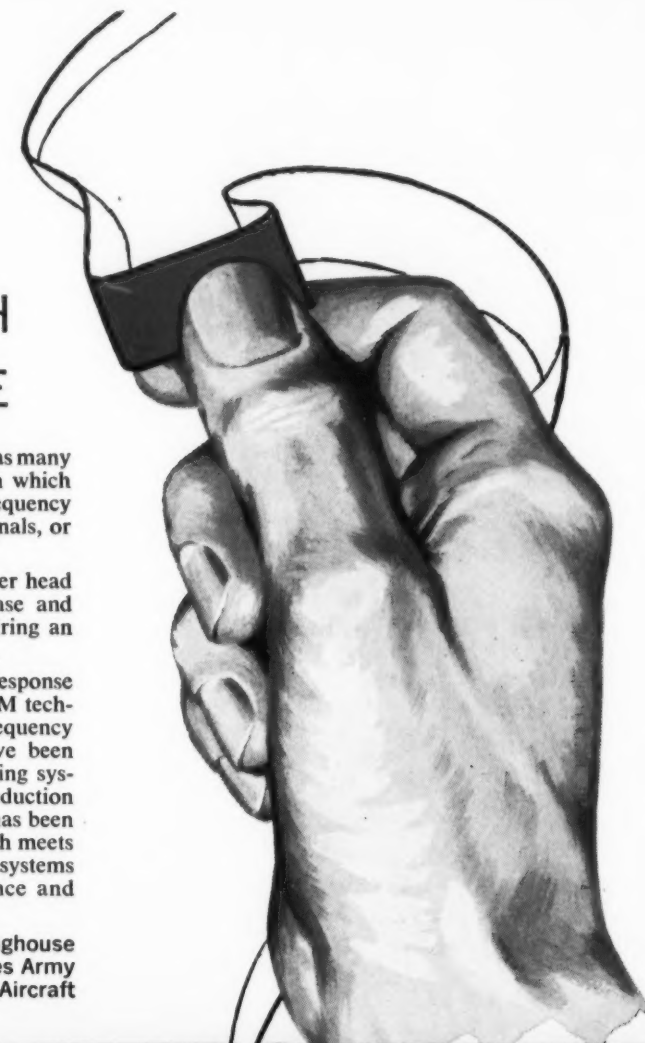
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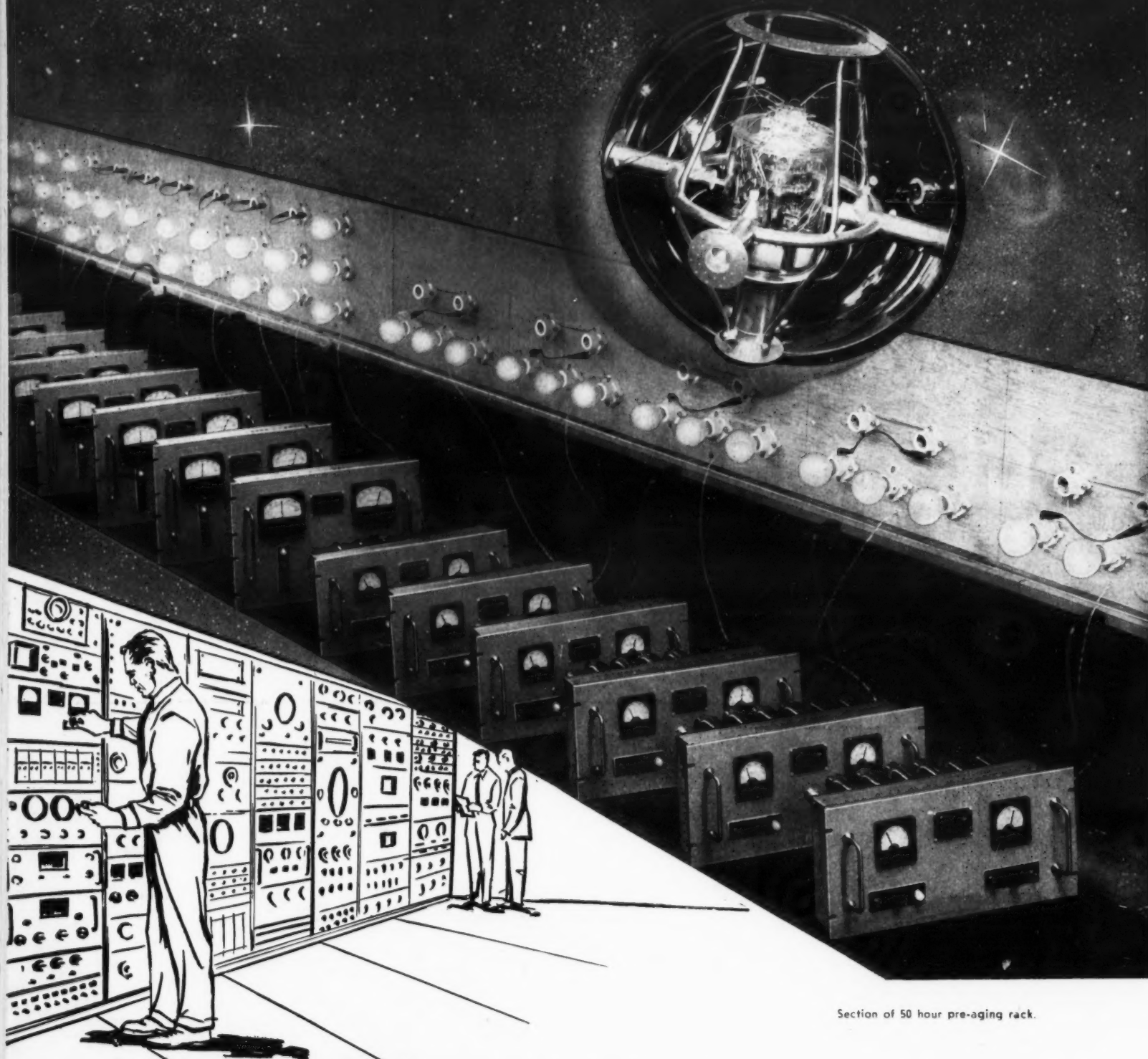
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